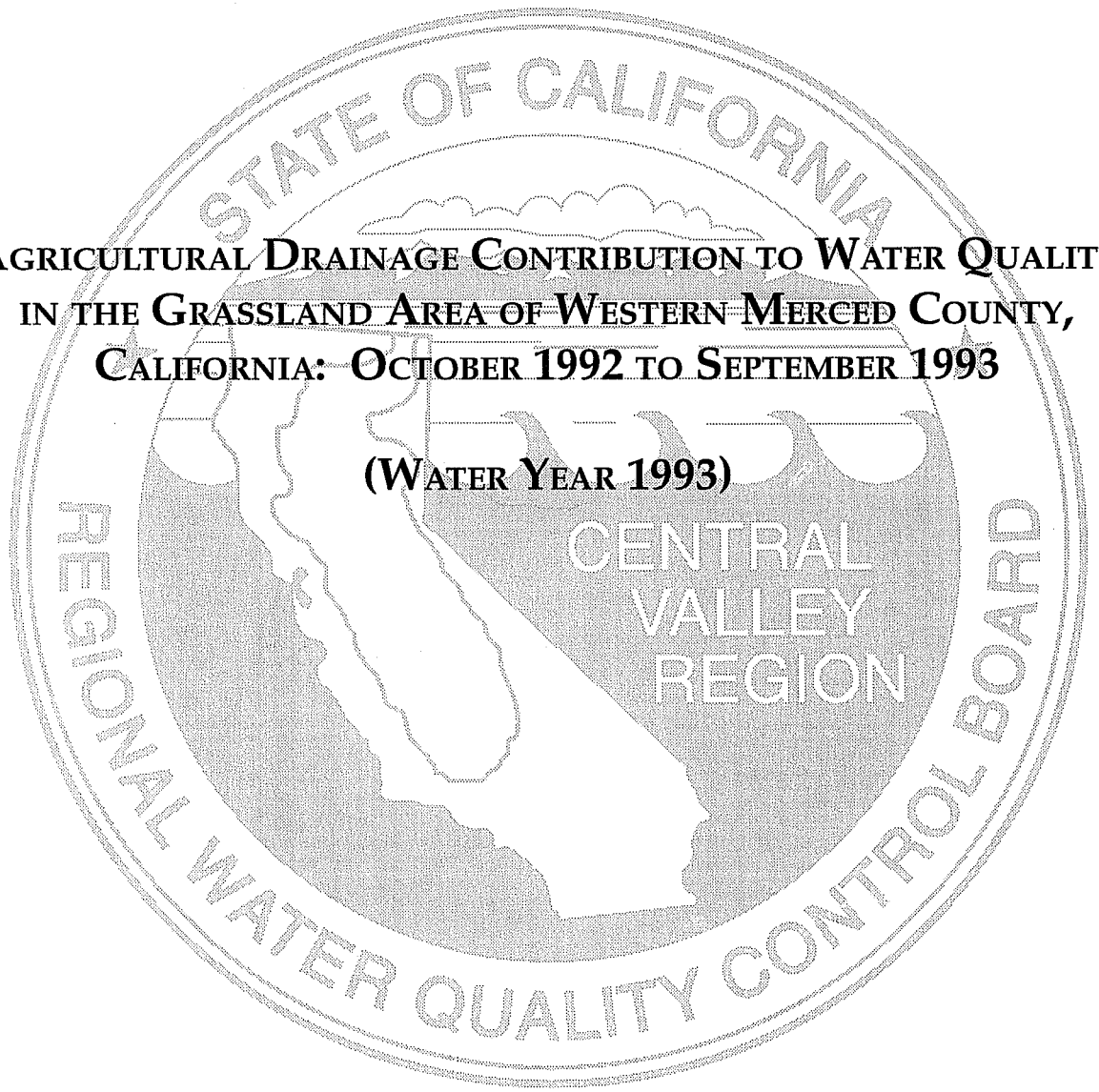
Staff Report of the

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD

CENTRAL VALLEY REGION



AGRICULTURAL DRAINAGE CONTRIBUTION TO WATER QUALITY IN THE GRASSLAND AREA OF WESTERN MERCED COUNTY, CALIFORNIA: OCTOBER 1992 TO SEPTEMBER 1993

(WATER YEAR 1993)

JANUARY 1995

DISCLAIMER

This publication is a technical report by staff of the California Regional Water Quality Control Board, Central Valley Region. No policy or regulation is either expressed or intended.

The staff involved in the preparation of this report are:

Jeanne Chilcott, Associate Land and Water Use Analyst
Joe Karkoski, Environmental Engineer, U.S. EPA
Mitchell R. Ryan, Environmental Evaluation Assistant

Many thanks to Alfonso Fragoso, Cindy Laguna, and Patricia Saelao, as well as other staff of the Agricultural Unit, who contributed their time and skill throughout the field sampling and quality control portions of this survey. Also special thanks to Della Kramer of our support staff, who consistently met tight deadlines during the entire production of this report.

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EXECUTIVE SUMMARY AND RECOMMENDATIONS

In May 1985, Regional Board staff began a water quality monitoring program to evaluate the effects of subsurface agricultural drainage on the water quality of the drains in the Grassland Area of western Merced County. This database is used in the development of future agricultural drainage reduction programs in the San Joaquin River Basin. Reports on this water quality survey have already been prepared and approved by the Board for Water Year (WY) 1986 through 1992. The current report covers WY 93 (October 1992 through September 1993), an above normal rainfall Water Year.

Agricultural lands east, west, and south of the Grassland Area discharge subsurface agricultural drainage water (tile drainage) and surface irrigation runoff (tailwater) to the Grassland Area. This drainage often contains high concentrations of salts, selenium, and other trace elements. This regional drainage flows north through the Grassland Area where it is carried by a network of canals which can divert water in a number of possible ways before it reaches Mud Slough (north) or Salt Slough and ultimately the San Joaquin River.

As previous studies and this study show, the highest constituent concentrations are found at the inflow monitoring stations near the southern boundary of the study area. This inflow water is generally a blend of subsurface tile drainage and surface runoff or operational spills from irrigation canals. Four of these inflow points carry a substantial portion of subsurface drainage water that has the highest concentrations of salts, boron, and selenium. Other inflows contain little selenium; however, elevated levels of salt and boron are present.

Water quality objectives are established in the San Joaquin River Basin Plan for selenium, boron, and molybdenum in Mud Slough (north) and Salt Slough. The Basin Plan selenium objective, which has a compliance date of October 1993, is 10 μg/L based on a monthly mean. The selenium levels in the sloughs vary depending on which slough is carrying drainage[1] from the drainage study area. During WY 93, all subsurface drainage was diverted to Salt Slough. The presence of drainage water in Salt Slough resulted in monthly mean selenium concentrations ranging between 0.7 and 32 μg/L depending on available dilution. With the absence of drainage water, Mud Slough (north) monthly selenium levels were less than 5 μg/L except during December 1992 when concentrations reached 30 μg/L selenium. The presence of subsurface drainage appears to have a direct effect on whether future selenium water quality objectives will be exceeded when they come into effect during WY 94.

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[1]The "drains" or "drainage water" will refer to the combined tail and tile water discharge from the following districts: Broadview W.D., the Camp 13 Study Area of Central California I.D. (CCID), Charleston D.D., Firebaugh Canal W.D., Pacheco W.D., and Panoche D.D.

The WY 94 boron objective will be 2.0 mg/L and the currently adopted molybdenum objective is 19 μg/L for both sloughs based on a monthly mean. With the absence of drainage water, boron and molybdenum levels in Mud Slough (north) were lower in WY 93 than in the previous two water years. Objectives, however, continue to be exceeded on a seasonal basis which indicates naturally elevated concentrations in Mud Slough (north). The concentration based objectives for these constituents may need to be reviewed and substantially revised based on background information.

In Salt Slough, the upcoming WY 94 boron objective was exceeded between March and August 1993. Drainage water was present during this time period. Data from WYs 91 and 92 indicate that a boron concentration of 2.0 mg/L can be met in Salt Slough with the absence of drainage water. The molybdenum objective was met at all times.

An analysis of loads of selenium, boron, and salt from the sloughs indicates that the trend toward significant reductions which took place between water years 1989 and 1992, has been reversed. Full water allotments to exchange and 50% allotments to federal contractors following two years of supply restrictions and six years of drought, resulted in altered management practices and a flushing of the system. Loading of salt, boron, and selenium increased dramatically over the previous water year (by 60, 62, and 76%, respectively) to approach levels not seen since WY 89. Constituent concentrations did not change appreciably between WY 92 and WY 93.

Other constituents analyzed during WY 93 (copper, chromium, lead, nickel, and zinc), do not appear to be at concentrations which would impact aquatic life due to the elevated hardness values in the channels surveyed. Selenium, boron, and salt loads as well as concentrations will continue to be reviewed and analyzed in future water years.

Channels which carry supply water for waterfowl habitat were monitored on a seasonal basis during WY 93. All supply sources had selenium concentrations below the 2.0 μg/L waterfowl habitat water quality objective during typical periods of flood-up (end of September through December) and irrigation of wetland grasses (May and June). Selenium concentrations reached slightly over 3.0 μg/L during February and March 1993 and corresponded to an increase in the Delta Mendota Canal which is the freshwater supply for the area.

INTRODUCTION

The Agricultural Unit of the Central Valley Regional Water Quality Control Board (Regional Board) initiated a water quality monitoring program in May 1985 to evaluate the effects of subsurface agricultural drainage on the water quality of the drains in the Grassland Area in western Merced County. The study area is located west of the San Joaquin River between Newman and Oro Loma, California (Figure 1). The purpose of this monitoring program is to compile an on-going database for selected inorganic constituents found in the agricultural drains discharging to and flowing through the Grassland Area. This database is used in the development and evaluation of agricultural drainage reduction programs in the San Joaquin River Basin. Information gathered under this program is also being used to develop a predictive model for determining maximum salt, selenium, and boron loads which could be discharged from the study area while still meeting downstream water quality objectives (Karkoski, 1994). This report contains laboratory results and a brief summary of the water quality analysis for samples collected during WY 93 (October 1992 through September 1993). Six previous reports (James, et al., 1988, Chilcott, et al., 1989, Westcot, et al., 1990, Westcot, et al., 1991, Westcot, et al., 1992, and Karkoski and Tucker, 1993) present data for the period May 1985 through September 1992 (WY 86 through WY 92).

STUDY AREA

The Grassland Area encompasses the Northern and Southern Divisions of the Grassland Water District and the farmlands adjacent to the District (Figure 1). Land in this area is primarily used for irrigated agriculture and managed wetlands.

Agricultural lands east, west, and south of the Grassland Area discharge subsurface agricultural drainage water (tile drainage) and surface runoff (irrigation tailwater) to the Grassland Area. This drainage often contains high concentrations of salts, selenium, and other trace elements. This regional drainage flows north through the Grassland Area where it is carried by a network of canals that can divert water in several possible ways before it reaches Mud Slough (north) or Salt Slough and ultimately the San Joaquin River.

There were 32 stations in the Grassland monitoring program as described by James, et al., 1988. They were divided into three categories: inflows to, internal flows within, and outflows from the Grassland Area. Inflow monitoring stations were located on drains that discharge into the Grassland Area and are mainly located at the southern end of the study area. Monitoring stations on the internal flow canals were located on drains within the Grassland Area that carry or could carry subsurface tile drainage as it passes through the area before discharging to the San Joaquin River. Outflow monitoring stations were located where drains or natural waterways flow out of the Grassland Area. Many of the internal flow stations described by James, et al. (1988), have been altered or dropped from the original monitoring program.

During WY 93, 12 inflow, five internal flow, and five outflow stations were monitored (Table 1). Most of the original inflow stations were maintained during the current survey. Internal flow stations are maintained to assess the approximate concentration of selenium in

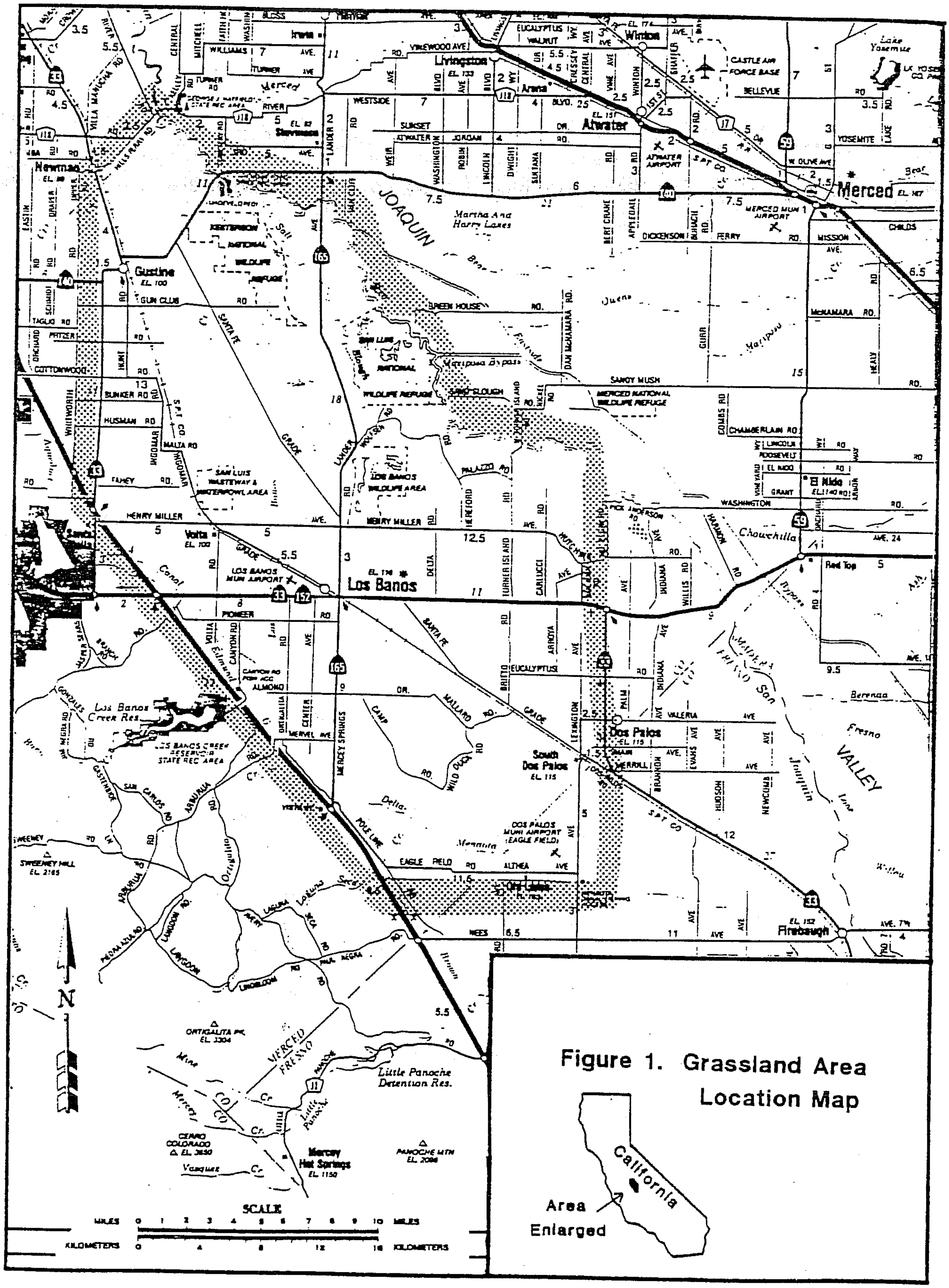


Figure 1. Grassland Area Location Map

Table 1. Water Quality Monitoring Sites in the Grassland Area for Water Year 1993.

Map Index	RWQCB Site I.D.	Site Name	Site Type
I-1	MER556	Main (Firebaugh) Drain @ Russell	Inflow
I-2	MER501	Panoche Drain	Inflow
I-3	MER552	Agatha Inlet (Mercy Springs)Drain	Inflow
I-4	MER506	Agatha Canal @ Mallard	Inflow
I-6	MER504	Hamburg Drain	Inflow
I-7	MER505	Camp 13 Slough	Inflow
I-8	MER502	Charleston Drain	Inflow
I-9	MER555	Almond Drive Drain	Inflow
I-10	MER509	Rice Drain	Inflow
I-11	MER521	Boundary Drain	Inflow
I-12	MER528	Salt Slough Ditch @ Hereford Road	Inflow
T-1	MER510	CCID Main @ Russell Avenue	Internal Flow
T-5	MER519	Santa Fe Canal @ Henry Miller Road	Internal Flow
T-7A	MER543	San Luis Canal @ Henry Miller Road	Internal Flow
T-7	MER527	San Luis Canal @ Highway 152	Internal Flow
T-13	**MER548**	**Porter-Blake Bypass**	**Internal Flow**
T-14	**MER537**	**San Luis Spillway Ditch @ Sante Fe Grade**	**Internal Flow**
0-1	MER551	Mud Slough (N) @ Newman Gun Club	Outflow
0-2A	MER542	Mud Slough @ San Luis Drain	Outflow
0-3	MER554	Los Banos Creek @ Highway 140	Outflow
0-4	MER531	Salt Slough @ Lander Avenue	Outflow
A	**MER536**	**Mud Slough Upstream of SLD Terminus**	**Outflow**
B	**MER535**	**San Luis Drain @ Terminus**	*
C	**MER534**	**San Luis Drain @ Highway 152**	*

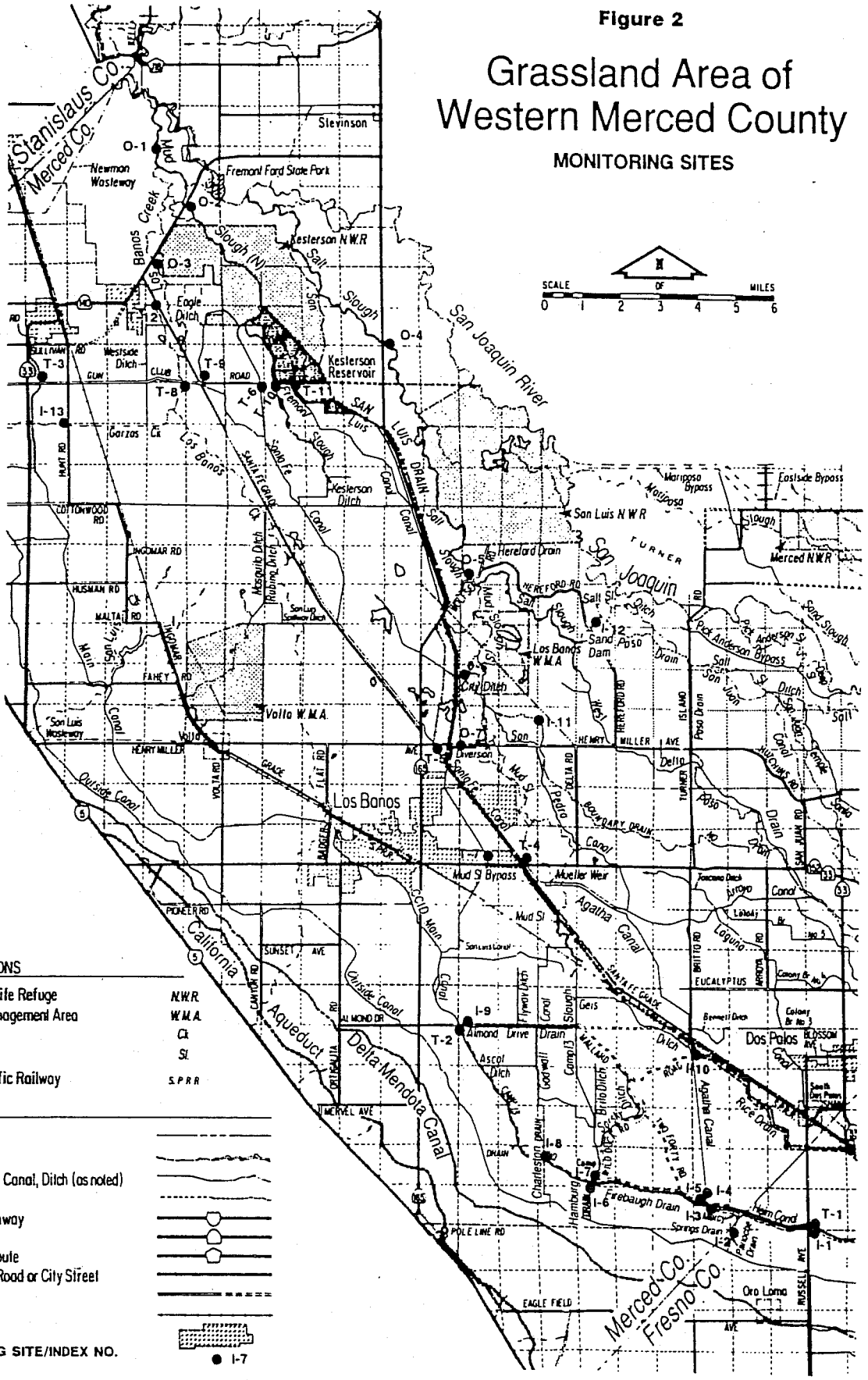
Highlighted stations were initiated in WY 93.

* No outflow from the San Luis Drain (SLD)

Figure 2

Grassland Area of Western Merced County

MONITORING SITES



water supply canals to the Grassland Area as well as to track movement of the drainage water. The only addition was the San Luis Spillway (T-14) which was monitored during October and November 1992 and September 1993 to determine water quality entering local duck clubs. The CCID Main Canal (T-1) is the main supply to the Grassland area and local duck clubs and is discussed in this report. The Porter-Blake Bypass (T-13), Santa Fe Canal at Henry Miller Road (T-5), San Luis Canal at Henry Miller Road (T-7A), and San Luis Canal at HWY 152 (T-7) were also surveyed during WY 93. Data for these latter four sites are on file at the Regional Board.

The outflow monitoring site at Mud Slough (north) at the San Luis Drain (0-2A) was maintained in order to tie in with the continuous flow monitoring station operated by the U.S. Geological Survey. Mud Slough (north) and Salt Slough are the only two tributaries to the San Joaquin River which drain the Grassland Area and are described in detail by James, et al. (1988) and Pierson, et al. (1989a and 1989b). Mud Slough (north) at the San Luis Drain (0-2A) and Salt Slough at Lander Avenue (0-4) are the principal stations in this monitoring program. These two sites best represent the water quality of the drainage leaving the Grassland Area. Los Banos Creek at HWY 140 (0-3) drains into Mud Slough (north) upstream of the San Joaquin River. Mud Slough at Newman Gun Club (0-1) represents the combined quality of Mud Slough (north) and Los Banos Creek.

The three San Luis Drain stations (A, B, and C) provide water quality information on seepage into the drain itself as well as concentrations in Mud Slough upstream of a potential discharge location. Currently, there is no outflow from the drain. Information gathered to date will provide background information should discharges from the drain be allowed in the future. Data for these sites will be evaluated and reported in a separate study at a later date.

Monitoring stations for water year 1993 (WY 93) are listed in Table 1 and depicted in Figure 2. Most stations have continuous data from May 1985 through September 1993. Stations which originated in WY 93 have been highlighted.

METHODS

Sampling

The frequency of sample collection for this monitoring program consisted of weekly and monthly grab samples. Water temperature, pH, electrical conductivity (EC), and sample time were recorded in the field for each site. There were 13 sites sampled weekly and an additional 11 sites sampled monthly. Laboratory analyses for total recoverable selenium, boron and electrical conductivity (EC)[2] were performed on all samples. Selected sites were also monitored for copper, chromium, nickel, lead, zinc and molybdenum on a monthly basis. Samples were collected in polyethylene bottles. The selenium and trace element sample bottles were acid washed and rinsed with de-ionized water in the laboratory before use. All sample bottles were rinsed three times with the water to be sampled prior to sample

[2] Electrical conductivity values reported in the Appendices are laboratory EC values.

collection. Selenium and trace element samples were preserved by lowering the pH to less than two using nitric acid fixation techniques. All samples were kept on ice until preservation or submittal to the laboratory.

A quality control and quality assurance program was conducted using blind spiked and split samples. Blind split samples were collected at 10 percent of the sites, and 50 percent of the blind splits were spiked with known concentrations of key constituents to evaluate analytical recoveries. Reported results fall within quality assurance tolerance guidelines outlined in Table 2.

TABLE 2

Quality Assurance Tolerance Guidelines

Constituent	Recovery Range at Low Levels (μg/L)*	Acceptable Blind Duplicate Spike Recovery Range
Copper	1-20 +/- 5	> 20 70-130%
Chromium	1-20 +/- 5	> 20 70-130%
Lead	5-25 +/- 8	> 25 60-140%
Molybdenum	1	90-110%
Nickel	5-25 +/- 6	>25 65-135%
Selenium	0.2	90-110%
Zinc	1-20 +/- 6	> 20 70-130%
Boron	50	85-115%
Chloride	5000	85-115%

* For certain constituents, recovery is expressed as an absolute value rather than a percentage at low levels. For example, if the result of copper analysis for a particular sample is 10 μg/L, a duplicate analysis must fall between 5 μg/L and 15 μg/L. If the sample is greater than 20 μg/L, recovery is expressed as a percent and must be between 70 and 130%. If a recovery range is not shown at low levels, the detection limit is given.

Load Calculations

The loads and flow weighted concentrations were calculated for selenium, boron and salt for Mud Slough (north) and Salt Slough and the total from the drains. Loads for selenium and boron were calculated in pounds and salt was calculated in tons. The flow weighted concentrations for salt and boron were calculated in units of mg/L and selenium was calculated in units of μg/L. The drains used in the load calculation were the following: Firebaugh Main Drain (includes Broadview, CCID, Firebaugh), Panoche Drain, Charleston Drain and Hamburg Drain (Pacheco). The total load from the drains were the summation of Main, Panoche, Charleston, and Hamburg drain loads minus the drainage water mixed with CCID supply water. A portion of the drain water mixed into CCID's supply canal (which is not sampled) is also routed to the Camp 13 ditch (which is sampled); therefore, when the drain water is mixed into CCID's supply canal then its quality can be assumed to be the same as the drain water in Camp 13 ditch.

Detailed methodologies for the load calculations can be found in Karkoski and Tucker, 1993, and Karkoski, 1994.

RESULTS

Following the trend found in other WYs, the highest concentrations of the measured constituents were found at the inflow monitoring stations near the southern boundary of the study area. The internal flow stations which carried supply water had the lowest measured constituent concentrations. Constituent concentrations of outflow monitoring stations varied depending on whether the channel carried drainage water from the study area. Water quality analysis results at the inflow, internal flow, and outflow monitoring stations will be discussed separately.

Water quality results for both minerals and trace elements are listed by site in Appendices A through C; Grassland inflows (Appendix A), internal flows (Appendix B), and outflows (Appendix C). The ranges, mean and median values for each measured constituent at each site are also shown in these appendices. For this study, electrical conductivity (EC) represented relative salinity; while boron, chloride, and sulfate were the primary mineral constituents of concern. Selenium and molybdenum were the primary trace elements of concern. The median mineral, trace element and hardness values for WY 93 are listed in Table 3 for each monitoring station. Since WY 93 was the first above normal rainfall year following six consecutive drought years, its median values have been compared to median values for the previous water years in Table 4.

Minerals

Inflow Monitoring Stations:

The inflow monitoring stations represent the quality of the agricultural drainage entering the Grassland Area. The first nine monitoring stations (I-1 to I-4, I-6 to I-10) listed in Table 1

Table 3. Median Constituent Concentrations for Waterways throughout the Grassland Watershed: WY93

Type	Station	EC (umhos/cm)	B	Cl	SO4	Se	Mo	Cr	Cu	Ni	Pb	Zn	Hardness mg/L
			mg/L			ug/L							
I	Main (Firebaugh) Drain	3530	5.1	342	972	52	19	27	14	24	<5	34	834
I	Panoche Drain	4800	7.7	620	1280	76	11	38	10	15	<5	11	1170
I	Mercy Springs (Agatha) Drain*	4780	8.4	633	1190	41	—	7	13	<10	<25	46	1130
I	Agatha Canal	3165	5.4	426	1050	23	8	—	11	—	—	—	855
I	Hamburg Drain	5020	6.3	723	1520	76	9	25	7	13	<5	23	1630
I	Camp 13	4020	6.2	414	997	56	10	—	11	—	—	—	939
I	Charleston Drain	4155	4.2	685	1450	70	8	15	7	14	<5	20	1590
I	Almond Drain	900	0.4	123	119	1.9	9	—	—	—	—	—	187
I	Rice Drain	2250	4.1	240	617	2.6	12	—	—	—	—	—	525
I	Boundary Drain	1043	0.46	160	125	1.1	—	—	—	—	—	—	232
I	Salt Slough @ Hereford	1060	0.35	149	120	0.8	—	—	6	—	—	—	686
T	San Luis Spillway	778	0.37	155	80.4	0.3	—	—	5	—	—	—	216
T	CCID Main Canal	820	0.35	77	83	1.4	—	—	11	—	—	—	155
O	Salt Slough @ Lander	2270	2.5	327	385	18	9	13	6	11	<5	13	470
O	Mud Slough @ Newman Gun Club	1980	1.5	382	558	3.0	9	6	2	<5	<5	4	509
O	Los Banos Creek	1480	1.3	182	193	1.0	—	—	—	—	—	—	280
O	Mud Slough @ San Luis Drain	2500	1.9	343	491	2.0	9	12	5	10	<5	9	454

* Site only sampled during November 1992

I = Inflow

T = Internal flow

O = Outflow

SLD = San Luis Drain site

Table 4

Median Constituent Concentrations for Grassland Area Canals & Streams: Water Years 1985-1993.

(Data for WY's 85, 86, and 87 from James et al., 1988, for WY 88 from Chilcott et. al., 1989, and for WY's 89, 90, and 91 from Westcot et al., 1990, 1991,1992 and, for WY92 from Karkoski and Tucker 1993).

Map ID	Monitoring Site / Water Year	Median Constituent Concentrations													
		EC	B	Cl	SO4	Se	Mo	Cr	Cu	Ni	Pb	Zn	U	V	Hardness
		umhos/cm	mg/L			ug/L									mg/L
I-1	Main (Firebaugh) Drain @ Russell														
	Dry WY 85	2400	3.2	230	693	35	--	--	--	--	--	--	--	--	--
	Wet WY 86	2700	3.5	250	900	46	14	16	9	27	--	14	--	--	--
	Critical WY 87	2600	3.4	270	630	42	9	19	9	22	--	28	--	--	--
	Critical WY 88	3000	3.6	320	790	49	10	22	12	22	<5	29	--	--	--
	Critical WY 89	2980	3.9	315	835	49	13	17	9	19	<5	23	--	--	--
	Critical WY 90	3400	4.6	370	1200	52	24	10	5	11	<5	13	--	--	--
	Critical WY 91	3450	4.6	440	1400	52	21	10	23	<5	21	18	16	12	940
	Critical WY 92	3700	5.2	319	849	59	28	14	8	17	<5	18	--	--	640
	Above Normal WY 93	3530	5.1	342	972	52	19	27	14	24	<5	34	--	--	834
I-2	Panoche Drain/O'Banion														
	Dry WY 85	3500	6.5	460	985	38	3	--	--	--	--	--	--	--	--
	Wet WY 86	3400	5.8	390	800	56	6	26	5.5	15	--	15	--	--	--
	Critical WY 87	4375	7.8	550	1075	47	3	40	10	13	--	18	--	--	--
	Critical WY 88	3650	6.4	440	890	54	3	43	12	21	<5	29	--	--	--
	Critical WY 89	4180	6.5	520	1000	69	6	32	5	8.0	<5	11	--	--	--
	Critical WY 90	4550	7.5	665	1400	72	8	32	4	9	<5	10	--	--	--
	Critical WY 91	4450	7.5	620	1300	64	8	3	20	<5	7	7	11	7	1200
	Critical WY 92	4870	8.0	655	1490	82	11	16	2.7	<5	<5	6	--	--	1200
	Above Normal WY 93	4800	7.7	620	1280	76	11	38	10	15	<5	11	--	--	1170
I-3	Mercy Springs Drain (Agatha Inlet Drain)														
	Dry WY 85	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Wet WY 86	3300	7.2	360	1000	14	10	7	5	13	--	10	--	--	--
	Critical WY 87	3125	7.0	302	800	6	16	5	3	7	--	3	--	--	--
	Critical WY 88	4150	8.6	540	1300	7.9	39	10	5	15	<5	12	--	--	--
	Critical WY 89	3655	7.6	435	895	6.7	--	--	--	--	--	--	--	--	--
	Critical WY 90	4910	8.4	640	1400	7.9	--	--	--	--	--	--	--	--	--
	Critical WY 91	3770	6.4	655	1095	4.7	--	--	--	--	--	--	--	--	985
	Critical WY 92	4470	7.4	600	1280	7.8	--	--	--	--	--	--	--	--	1050
	*Above Normal WY 93	4780	8.38	633	1190	41.3	--	7	13	<10	<25	46	--	--	1130
I-4	Agatha Canal														
	Dry WY 85	2600	4.9	315	1100	26	1	--	--	--	--	--	--	--	--
	Wet WY 86	3300	5.6	400	900	44	<5	13	9	21	--	16	--	--	--
	Critical WY 87	3305	5.6	410	760	38	6	22	7	12	--	12	--	--	--
	Critical WY 88	3550	5.6	430	895	39	3	--	--	--	--	--	--	--	--
	Critical WY 89	880	0.36	130	100	2.9	2	--	--	--	--	--	--	--	--
	Critical WY 90	4040	6.6	480	1100	26	8	--	--	--	--	--	--	--	--
	Critical WY 91	4295	6.6	515	1100	53	9	--	--	--	--	--	--	--	1025
	Critical WY 92	3440	5.6	378	726	31	9	--	--	--	--	--	--	--	619
	Above Normal WY 93	3165	5.4	426	1045	23	8	--	11	--	--	--	--	--	855
I-6	Hamburg Drain														
	Dry WY 85	3200	3.8	435	900	47	6	--	--	--	--	--	--	--	--
	Wet WY 86	3250	4.0	400	1000	51	4	13	5	10	--	13	--	--	--
	Critical WY 87	3345	3.7	420	925	58	<5	17	5	8	--	10	--	--	--
	Critical WY 88	3600	4.1	450	1050	56	5	11	5	<5	<5	6	--	--	--
	Critical WY 89	5120	5.7	660	1500	95	5	16	2	<5	<5	6	--	--	--
	Critical WY 90	4740	5.4	720	1400	84	5	14	1	<5	<5	6	--	--	--
	Critical WY 91	5540	5.6	730	1675	99	7	1	11	1	<5	<5	19	6	1650
	Critical WY 92	5090	5.2	725	1580	86	9	20	9	13	<5	18	--	--	1650
	Above Normal WY 93	5020	6.3	723	1515	76	9	25	7	13	<5	23	--	--	1625

* only sampled during November 1992

Table 4 continued:

Map ID	Monitoring Site / Water Year	Median Constituent Concentrations													
		EC	B	Cl	SO4	Se	Mo	Cr	Cu	Ni	Pb	Zn	U	V	Hardness
		umhos/cm	----------mg/L----------			----------ug/L----------									mg/L
I-7	Camp 13 Slough														
	Dry WY 85	2550	3.4	280	745	32	4	--	--	--	--	--	--	--	--
	Wet WY 86	2950	3.9	375	905	43	<5	14	7	20	--	16	--	--	--
	Critical WY 87	2650	3.7	280	590	43	6	30	11	13	--	19	--	--	--
	Critical WY 88	4400	6.2	500	1050	43	4	--	--	--	--	--	--	--	--
	Critical WY 89	3750	5.2	440	940	59	8	--	--	--	--	--	--	--	--
	Critical WY 90	3440	4.9	455	1010	54	9	--	--	--	--	--	--	--	--
	Critical WY 91	3960	5.5	560	1300	55	21	--	--	--	--	--	--	--	1200
	Critical WY 92	4130	5.5	492	1240	64	11	--	--	--	--	--	--	--	1100
	Above Normal WY 93	4020	6.2	414	997	56	10	--	11	--	--	--	--	--	939
I-8	Charleston Drain														
	Dry WY 85	3900	2.6	395	1275	48	--	--	--	--	--	--	--	--	--
	Wet WY 86	4500	4.7	510	1580	93	8	9	10	14	--	18	--	--	--
	Critical WY 87	3855	4.2	480	1035	79	2	32	12	22	--	50	--	--	--
	Critical WY 88	4450	4.5	520	1300	71	3	31	13	27	--	47	--	--	--
	Critical WY 89	4400	3.8	520	1400	66	3	25	12	17	<5	33	--	--	--
	Critical WY 90	4350	3.7	525	1400	69	6	14	3	8	<5	17	--	--	--
	Critical WY 91	4370	4.2	645	1700	60	8	3	10	<5	7	11	20	--	1600
	Critical WY 92	4283	4.3	609	1300	66	8	10	7	9	<5	21	--	--	1310
	Above Normal WY 93	4155	4.2	685	1450	70	8	15	7	14	<5	20	--	--	1590
I-9	Almond Drive Drain														
	Dry WY 85	1520	1.6	160	340	2.0	--	--	--	--	--	--	--	--	--
	Wet WY 86	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Critical WY 87	1925	2.1	224	395	4.8	5	28	11	21	--	25	--	--	--
	Critical WY 88	2300	2.1	230	460	4.6	--	18	7	13	--	15	--	--	--
	Critical WY 89	2160	2.2	190	420	3.7	--	--	--	--	--	--	--	--	--
	Critical WY 90	1320	0.91	155	220	2.3	--	--	--	--	--	--	--	--	--
	Critical WY 91	1415	1	200	250	2.9	--	--	--	--	--	--	--	--	330
	Critical WY 92	1670	1.5	220	320	2.2	--	--	--	--	--	--	--	--	330
	Above Normal WY 93	900	0.40	123	119	1.9	9	--	--	--	--	--	--	--	187
I-10	Rice Drain														
	Dry WY 85	2450	5.7	245	715	2.5	--	--	--	--	--	--	--	--	--
	Wet WY 86	3300	8.1	350	1080	3.0	14	5	6	23	--	13	--	--	--
	Critical WY 87	2500	6.1	260	550	2.6	11	3	3	6	--	<1	--	--	--
	Critical WY 88	2790	5.1	310	700	2.6	15	--	--	--	--	--	--	--	--
	Critical WY 89	2745	5.4	280	673	3.1	14	--	--	--	--	--	--	--	--
	Critical WY 90	3050	5.4	350	855	2.7	16	--	--	--	--	--	--	--	--
	Critical WY 91	2640	4.7	420	1145	2.6	22	--	--	--	--	--	--	--	860
	Critical WY 92	3000	5.9	400	868	3.4	20	--	--	--	--	--	--	--	700
	Above Normal WY 93	2250	4.1	240	617	2.6	12	--	--	--	--	--	--	--	525
I-11	Boundary Drain														
	Dry WY 85	1090	0.45	195	135	1.0	--	--	--	--	--	--	--	--	--
	Wet WY 86	1710	0.65	250	210	1.0	6	2	7	9	--	14	--	--	--
	Critical WY 87	1250	0.54	200	145	1.6	4	<1	2	<5	--	3	--	--	--
	Critical WY 88	1470	0.50	230	180	1.4	6	--	--	--	--	--	--	--	--
	Critical WY 89	1435	0.53	240	190	1.0	--	--	--	--	--	--	--	--	--
	Critical WY 90	1500	0.44	250	175	0.9	--	--	--	--	--	--	--	--	--
	Critical WY 91	1420	0.44	233	175	0.8	--	--	--	--	--	--	--	--	280
	Critical WY 92	1330	0.48	237	164	0.8	--	--	--	--	--	--	--	--	290
	Above Normal WY 93	1043	0.46	160	125	1.1									232
I-12	Salt Slough @ Hereford														
	Dry WY 85	850	0.37	120	100	1.0	--	--	--	--	--	--	--	--	--
	Wet WY 86	785	0.33	100	99	1.0	<5	3	5	9	--	22	--	--	--
	Critical WY 87	1000	0.39	130	120	1.4	3	1	2	<5	--	2	--	--	--
	Critical WY 88	1150	0.38	160	140	1.2	5	--	--	--	--	--	--	--	--
	Critical WY 89	1070	0.36	160	140	1.2	--	--	--	--	--	--	--	--	--
	Critical WY 90	1030	0.30	160	110	0.6	--	--	--	--	--	--	--	--	--
	Critical WY 91	1045	0.30	180	130	0.9	--	--	--	--	--	--	--	--	260
	Critical WY 92	1140	0.37	180	125	1.0	--	--	--	--	--	--	--	--	285
	Above Normal WY 93	1060	0.35	149	120	0.8	--	--	6	--	--	--	--	--	214

Table 4 continued:

Map ID	Monitoring Site / Water Year	Median Constituent Concentrations													
		EC	B	Cl	SO4	Se	Mo	Cr	Cu	Ni	Pb	Zn	U	V	Hardness
		umhos/cm	----------mg/L----------			----------ug/L----------									mg/L
T-1	CCID Main Canal														
	Dry WY 85	430	0.21	72	35	<1	--	--	--	--	--	--	--	--	--
	Wet WY 86	385	0.21	53	47	1.3	<5	3	3	5	--	8	--	--	--
	Critical WY 87	570	0.28	65	58	2.2	<5	1	3	<5	--	3	--	--	--
	Critical WY 88	760	0.29	120	65	1.7	--	--	--	--	--	--	--	--	--
	Critical WY 89	700	0.26	94	68	1.7	--	--	--	--	--	--	--	--	--
	Critical WY 90	680	0.32	120	93	2.3	--	--	--	--	--	--	--	--	--
	Critical WY 91	710	0.27	135	86	1.5	--	--	--	--	--	--	--	--	150
	Critical WY 92	800	0.38	130	110	2.0	--	--	--	--	--	--	--	--	170
	Above Normal WY 93	820	0.35	77	83	1.4	--	--	11	--	--	--	--	--	155
T-14	San Luis Spillway Ditch @ Santa Fe Grade														
	Above Normal WY 93	778	0.37	155	80.4	0.3	--	--	5	--	--	--	--	--	216
O-1	Mud Slough @ NGC														
	Dry WY 85	-	--	--	--	--	--	--	--	--	--	--	--	--	--
	Wet WY 86	1800	2.0	215	330	4.0	5	9	5	11	--	15	--	--	--
	Critical WY 87	2600	2.4	300	420	5.1	13	7	4	10	--	1	--	--	--
	Critical WY 88	2480	2.2	330	440	4.7	--	--	--	--	--	--	--	--	--
	Critical WY 89	2310	1.7	325	385	2.1	--	--	--	--	--	--	--	--	--
	Critical WY 90	2480	2.1	335	510	4.3	10	--	--	--	--	--	--	--	--
	Critical WY 91	3540	3.2	540	905	3.9	15	--	--	--	--	--	--	--	780
	Critical WY 92	3130	2.6	450	663	2.3	--	--	--	--	--	--	--	--	605
	Above Normal WY 93	1980	1.5	382	558	3.0	9	6	2	<5	<5	4	--	--	509
O-2A	Mud Slough @ SLD														
	Dry WY 85	2600	3.1	305	525	13	--	--	--	--	--	--	--	--	--
	Wet WY 86	2300	3.0	280	630	8.5	8	6	5	14	--	11	--	--	--
	Critical WY 87	2600	3.0	320	540	17	9	12	9	11	--	7	--	--	--
	Critical WY 88	2820	2.7	350	510	9.3	11	--	--	--	--	--	--	--	--
	Critical WY 89	3000	2.4	425	480	2.1	11	10	4	<5	12	12	--	--	--
	Critical WY 90	3060	3.4	410	590	5.2	12	6	2	8	<5	7	--	--	--
	Critical WY 91	4030	4.4	640	1000	2.4	27	3	5	<5	6	5	7	10	820
	Critical WY 92	3130	2.5	460	660	1.5	22	6	4	10	<5	8	--	--	630
	Above Normal WY 93	2495	1.9	343	491	2.0	9	12	5	10	<5	9	--	--	454
O-3	Los Banos Ck/HWY 140														
	Dry WY 85	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Wet WY 86	2200	2.3	430	300	1.0	<5	6	8	18	--	17	--	--	--
	Critical WY 87	1855	1.6	215	215	1.4	--	--	--	--	--	--	--	--	--
	Critical WY 88	1690	1.2	230	210	1.1	--	--	--	--	--	--	--	--	--
	Critical WY 89	1630	1.0	240	200	0.9	--	--	--	--	--	--	--	--	--
	Critical WY 90	1870	1.2	210	290	0.8	--	--	--	--	--	--	--	--	--
	Critical WY 91	2745	1.6	490	495	1.0	14	--	--	--	--	--	--	--	605
	Critical WY 92	1500	1.4	--	--	1.1	--	--	--	--	--	--	--	--	400
	Above Normal WY 93	1478	1.3	182	193	1.0	--	--	--	--	--	--	--	--	280
O-4	Salt Slough @ Lander														
	Dry WY 85	1250	0.96	185	195	4.5	--	--	--	--	--	--	--	--	--
	Wet WY 86	1610	1.3	240	245	7.4	7	4	6	12	--	18	--	--	--
	Critical WY 87	1720	1.7	250	350	12	6	6	4	6	--	4	--	--	--
	Critical WY 88	1940	1.9	260	385	13	6	--	--	--	--	--	--	--	--
	Critical WY 89	2040	1.9	270	430	15	6	13	6	1	12	18	--	--	--
	Critical WY 90	2340	2.3	340	525	15	7	10	4	9	<5	15	--	--	--
	Critical WY 91	2460	2	335	370	15	11	2	3	<5	<5	5	12	6	460
	Critical WY 92	2420	2.1	400	445	13	11	6	3	8	<5	8	--	--	590
	Above Normal WY 93	2270	2.5	327	385	18	9	13	6	11	<5	13	--	--	470

represent inflow into the South Grassland Area. The remaining two inflow stations (I-11 and I-12) either discharge to sloughs or the North Grassland Area (Figure 2).

Continuing the trend found in previous WYs, the inflows that carry a substantial portion of subsurface drainage water, Main (Firebaugh) (I-l), Panoche (I-2), Hamburg (I-6), and Charleston Drains (I-8), had elevated salinity levels. Hamburg Drain had the highest median EC (5,020 μmhos/cm), chloride (723 mg/L), hardness (1,630 mg/L) and sulfate (1,520 mg/L) values. Panoche Drain had the highest median boron (8.4 mg/L) value.

Internal Flow Monitoring Stations:

Two internal flow sites (the San Luis Spillway and the CCID Main) were seasonally monitored during WY 93. These channels are the major sources of supply water for locally managed duck clubs. Salinity and boron concentrations remained low in the channels. Median electrical conductivity was 778 μmhos/cm and 820 μmhos/cm for the Spillway and CCID Main, respectively, while median boron concentrations were 0.37 mg/L and 0.35 mg/L, respectively.

Outflow Monitoring Stations:

All of the outflow sites had elevated levels of salinity and minerals (Table 3). Mud Slough (north) at the San Luis Drain (0-2A) and Salt Slough at Lander (0-4) are both located near continuous flow meters making them valuable stations to determine constituent loads leaving the Grasslands Area.

During WY 93, Mud Slough (north) had EC values ranging from 810 to 7,250 μmhos/cm with a median of 2,500 μmhos/cm. Boron at this site ranged from 0.27 to 6.4 mg/L with a median value of 1.9 mg/L.

Salt Slough had EC values ranging from 905 to 3,970 μmhos/cm with a median value of 2,270 μmhos/cm. Boron concentrations at Salt Slough ranged from 0.51 to 2.5 mg/L with a median of 2.5 mg/L.

All available mineral information for the outflow sites during WY 93 has been tabulated in Appendix C.

Trace Elements

Although selenium was monitored at every site and molybdenum at most sites, analyses of additional trace elements were limited based on the overall low concentrations found by James, et al. (1988). Total recoverable selenium, molybdenum, copper, chromium, lead, nickel, and zinc are listed in Appendices A through C for inflow, internal flow, and outflow monitoring stations, respectively. The ranges, mean and median concentrations for the trace elements measured at each station are also listed in these appendices. The median trace element concentrations at each station for WY 93 are tabulated in Table 3.

Inflow Monitoring Stations:

The highest median trace element concentrations occurred at the South Grassland inflow stations (I-l to I-10), where the median selenium values ranged from 1.9 μg/L at Rice Drain (I-10) to 76 μg/L at both Panoche Drain (I-2) and Hamburg Drain (I-6). The Main (I-l), Panoche (I-2), Hamburg (I-6), and Charleston (I-8) Drains all had high median selenium concentrations. As with salinity and boron, the concentrations vary depending upon the amount of dilution water and quality of the tile water in the drain at the time of sampling. Concentrations in excess of 100 μg/L have been found at the Main Drain (24% of the time), Charleston Drain (11%), Hamburg Drain (28%), and Panoche Drain (20%). For the Main, Charleston, and Panoche Drains, the selenium concentrations exceeding 100 μg/L occurred between December and April with the majority in April. In contrast, selenium concentrations in excess of 100 μg/L occurred from July through September in the Hamburg Drain. The variation is likely due to the amount of spill water available for dilution during the various times of year within each of the smaller drainage areas.

Inflow sites that carry drainage from Sierra Nevada deposits (Rice Drain, Boundary Drain and Salt Slough at Hereford) continue to contain the lowest median selenium concentrations. Median selenium concentrations for these sites remained below 3.0 μg/L throughout WY 93.

The Main Drain (I-l) and Rice Drain (I-10) had the highest median molybdenum concentrations at 19 μg/L and 12 μg/L, respectively. The remaining inflow drains had median molybdenum concentrations ranging from 8 μg/L to 11 μg/L.

In addition to selenium and molybdenum, copper, chromium, nickel, lead, and zinc were analyzed monthly at the four major subsurface drainage inflows (Main, Panoche, Hamburg and Charleston Drains). Based on the extreme hardness of the water from the inflow stations, toxicity from copper, nickel, lead, and zinc is not expected (Marshack, 1993). Median total recoverable chromium values were greater than the chronic toxicity value for hexavalent chromium (11 μg/L) during WY 93, with total chromium median values ranging from 15 μg/L to 38 μg/L. Since analyses did not include quantification of the different species of chromium for these sites, it is not known whether hexavalent chromium is high enough to cause toxicity.

Internal Flow Monitoring Stations:

Selenium was the only trace element measured consistently at both internal flow monitoring stations. The San Luis Spillway which was monitored during the months it delivered flood up water to duck clubs, contained very low levels of selenium. Selenium concentrations in the Spillway ranged from 0.2 to 1.5 μg/L with a median concentration of 0.3 μg/L. The CCID Main Canal was monitored monthly with selenium concentrations ranging from less than 0.2 μg/L to 3.3 μg/L with a median of 1.3 μg/L.

Outflow Monitoring Stations:

The outflow monitoring stations, as mentioned earlier, are related to one of two tributaries of the San Joaquin River; the outflow through Salt Slough (site 0-4) and those that outflow through Mud Slough (north), (sites 0-1 through 0-3) as described in Table 1.

Selenium was monitored at all four outflow stations, while molybdenum, copper, chromium, nickel, lead, and zinc were monitored monthly at three stations (0-1, 0-2A and 0-4). The median trace element concentrations detected during this study are tabulated in Table 3.

At the furthest downstream monitoring station (on Salt Slough at Lander Avenue (0-4)), selenium concentrations ranged from 0.5 to 42 μg/L with a median of 18 μg/L. Selenium concentrations at Mud Slough (north) at the San Luis Drain (0-2A) ranged from 0.8 to 59 μg/L with a median of 2.0 μg/L. Los Banos Creek flows into Mud Slough (north) downstream of the Mud Slough (north) monitoring station near the San Luis Drain. The creek, along with any groundwater seepage, can have a diluting effect on the slough with respect to selenium, as measured at the Newman Land and Cattle Company station (0-1). Los Banos Creek receives its flow from the western portion of the North Grassland Area and from areas west of the study area. The creek receives little subsurface drainage. In WY 93, selenium concentrations range from 0.4 to 1.7 μg/L with a median of 1.0 μg/L at the Los Banos Creek at Highway 140 station (0-3). The downstream Mud Slough (north) station (0-1) had selenium concentrations similar to those found upstream of Los Banos Creek.

Molybdenum, copper, chromium, lead, nickel, and zinc were analyzed monthly at Salt Slough at Lander Avenue and Mud Slough (north) at the San Luis Drain. Molybdenum concentrations were the highest in Mud Slough (north), peaking at 46 μg/L with a median of 9 μg/L. All molybdenum concentrations at Salt Slough were reported at less than 15 μg/L with a median of 9 μg/L with the highest concentrations occurring between December 1992 and February 1993.

As is the case with the inflow stations, concentrations recorded for copper, nickel, lead, and zinc would not be expected to cause toxicity due to the high hardness of the water in the sloughs. Total recoverable chromium concentrations in the sloughs did exceed 11 μg/L (the chronic toxicity value of hexavalent chromium) in both sloughs reaching a maximum of 27 μg/L in Mud Slough (north) during August 1993.

LOADS

Between WY 89 and WY 92, flow weighted concentrations from the drains increased for boron, selenium and salt while the respective loads decreased (Karkoski et al., 1994). WY 93 changed this trend. Figures 3, 4, and 5, demonstrate that for salt, boron, and selenium, respectively, flow weighted concentrations remained virtually the same, while loads in the sloughs and from the drains increased to levels not seen since WY 89. The increase in overall loading over previous water years may reflect the advent of an above normal rainfall year after six continuous drought years.

Figure 3. Annual Salt Loads and Concentrations for Drainers and Sloughs

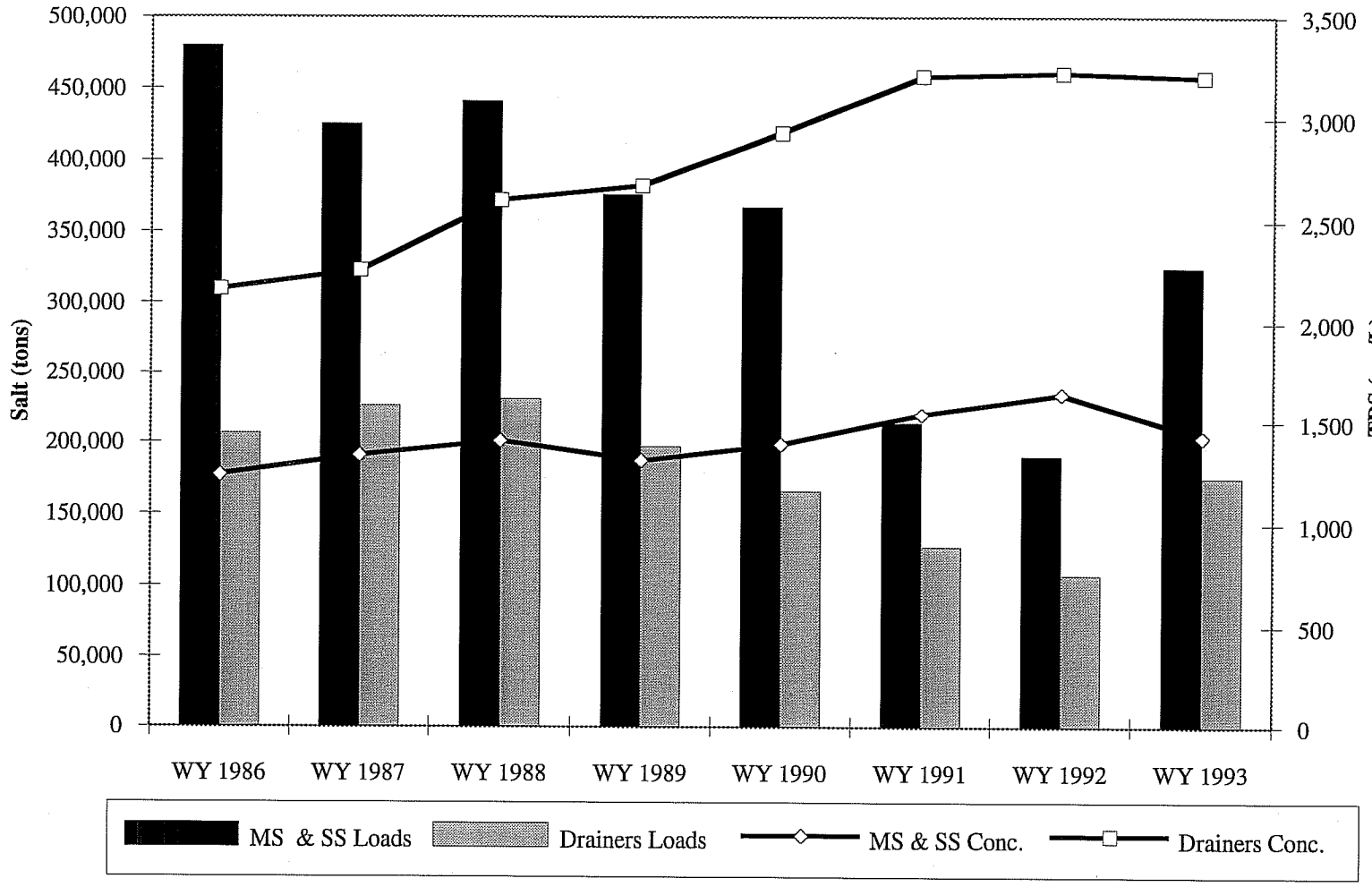


Figure 4. Annual Boron Loads and Concentrations for Drainers and Sloughs

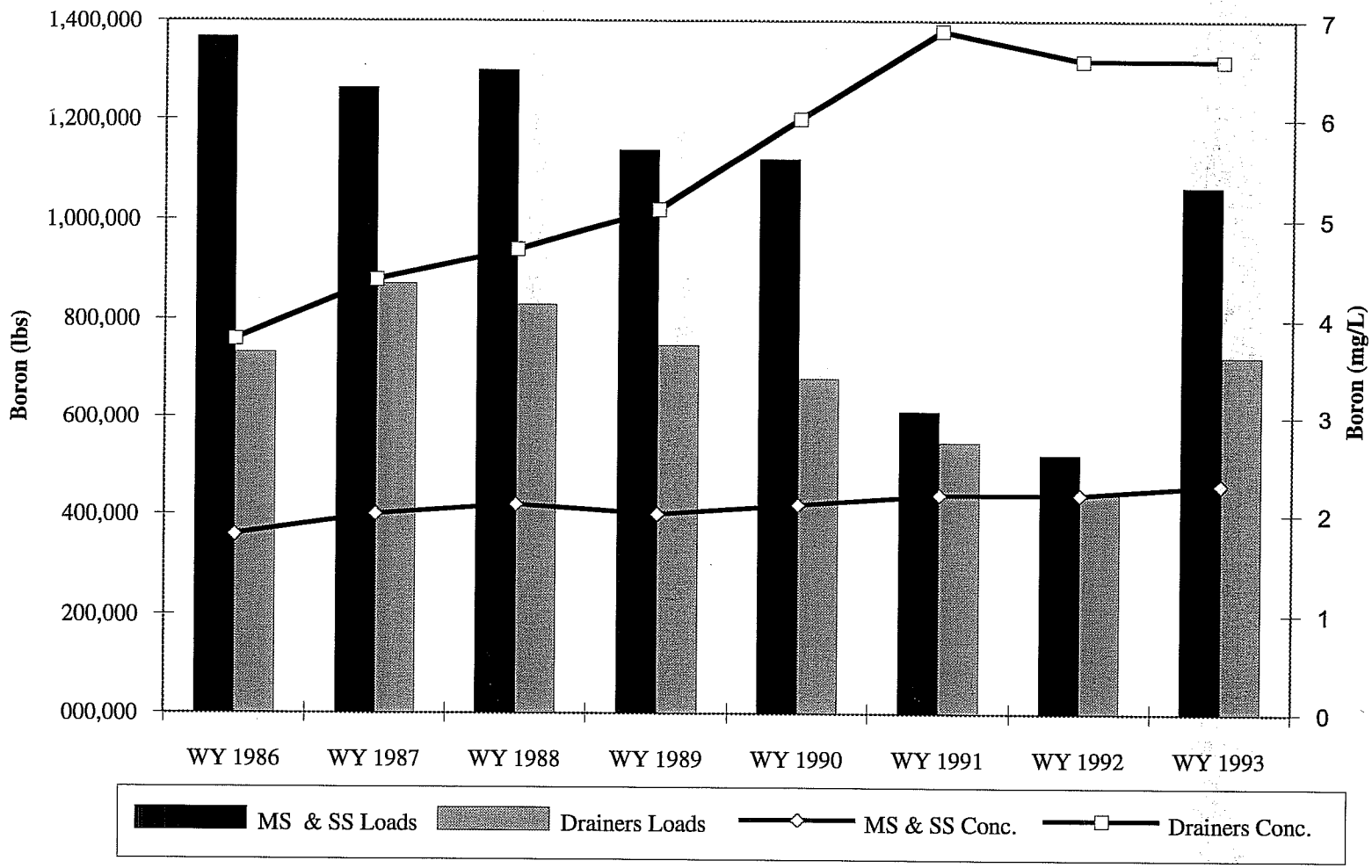
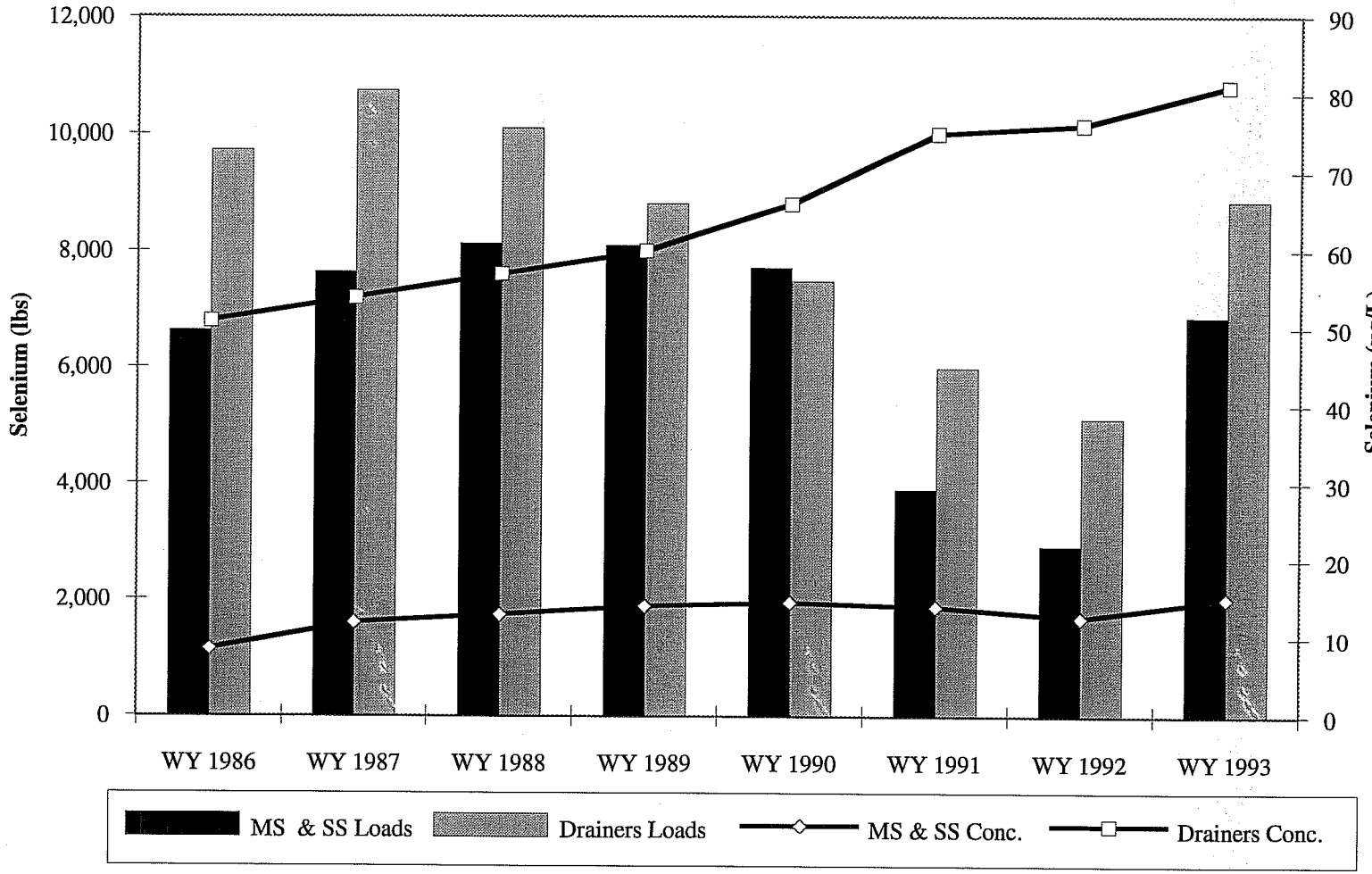


Figure 5. Annual Selenium Loads and Concentrations for the Drainers and Sloughs



The loads of boron and salt remain higher in Mud Slough (north) and Salt Slough than those from the drains; whereas, the normal selenium load from Mud Slough (north) and Salt Slough remains lower than those from the drains. Salt and boron is ubiquitous throughout the Grassland watershed. Selenium, in contrast, is primarily found in the Drainage Study Area (DSA), a subwatershed of the Grassland watershed. As the two major drainage arteries for the entire watershed, Mud Slough (north) and Salt Slough transport all drainage to the San Joaquin River. While the total salt and boron loads can be expected to be higher from the overall watershed than just the DSA, the decrease in selenium loads between the DSA and the San Joaquin River (Figure 5) remains unexplained. The U.S. Bureau of Reclamation is continuing to study potential mechanisms involved in a selenium sink as discussed in Karkoski and Tucker (1994).

DISCUSSION

WY 93 was the first above normal rainfall year after six consecutive critical water years. WYs 91 and 92 evoked a 75% water allocation for the exchange contractors (Firebaugh Canal W.D. and CCID) and 25% water allocation for the Federal contractors (Broadview W.D., Charleston D.D., Pacheco W.D., and Panoche D.D.). During WY 93, the exchange contractors received a full water allotment and Federal contractors received 50% of their anticipated water allotment and altered their management practices in response.

The combined effects of previously reduced water supplies with improved on-farm irrigation practices followed by full water allotments can be seen in Figures 3-5 and Table 5. Between WYs 89[3] and 92, significant (41 to 45%) load reductions from the drains occurred. At the same time, constituent concentrations increased (22 to 29%). The increased constituent concentrations were likely due to the reduced amount of higher quality tailwater in the drains. Tailwater reduction would occur as irrigation management improves.

During WY 93, average loading from the DSA increased 66% over WY 92, while the constituent concentrations either remained constant or increased slightly. Total flow from the drains equalled 40,657 ac-ft which was an increase of 64% over WY 92. The total WY 93 discharge from the drains was 26% less than flows recorded in WY 89 (the final year of full water allotment before the drought) and although constituent loads also decreased as compared to WY 89 for salt and boron (-12% and -4%, respectively), selenium loads did not. During WY 93, selenium loads approximately equalled those in WY 89.

The increased water supplies during WY 93 appears to have triggered a flushing of salts, boron, and selenium from the DSA. The significant loading increases parallel the increased flows from the system.

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[3]WY 89 was chosen as a base year, since Drainage Operation Plans and the implementation of best management practices were required by the Basin Plan beginning in calendar year 1990.

Table 5
Annual Salt, Boron and Selenium Loads and Concentrations for the Sloughs and Drainage Service Area (DSA)
WYs- 1986-1993

Salt Loads and Concentrations

Water Year	MS+SS Loads Tons	DSA Loads Tons	MS+SS % Change from WY 89	DSA % Change from WY 89	MS+SS Conc. mg/L	DSA Conc. mg/L	MS+SS % Change from WY 89	DSA % Change from WY 89
WY 1986	479,682	206,476	27%	5%	1,241	2,168	-5%	-19%
WY 1987	424,929	226,597	13%	15%	1,336	2,261	2%	-16%
WY 1988	441,079	231,348	17%	17%	1,407	2,604	7%	-3%
WY 1989	376,269	197,161	0%	0%	1,309	2,677	0%	0%
WY 1990	367,789	166,324	-2%	-15%	1,389	2,933	6%	10%
WY 1991	214,272	127,744	-43%	-35%	1,542	3,209	18%	20%
WY 1992	190,926	108,019	-49%	-45%	1,643	3,227	26%	21%
WY 1993	325,536	175,740	-13%	-11%	1,425	3,203	9%	20%

Boron Loads and Concentrations

Water Year	MS+SS Loads lbs	DSA Loads lbs	MS+SS % Change from WY 89	DSA % Change from WY 89	MS+SS Conc. mg/L	DSA Conc. mg/L	MS+SS % Change from WY 89	DSA % Change from WY 89
WY 1986	1,368,000	733,000	20%	2%	1.8	3.8	-10%	-25%
WY 1987	1,265,000	872,000	13%	17%	2.0	4.4	0%	-14%
WY 1988	1,301,000	830,000	14%	11%	2.1	4.7	5%	-8%
WY 1989	1,139,000	748,000	0%	0%	2.0	5.1	0%	0%
WY 1990	1,121,000	680,000	-2%	-9%	2.1	6.0	5%	18%
WY 1991	612,000	548,000	-46%	-27%	2.2	6.9	10%	35%
WY 1992	522,000	443,000	-54%	-41%	2.2	6.6	10%	29%
WY 1993	1,066,000	725,000	-6%	-3%	2.3	6.6	15%	29%

Selenium Loads and Concentrations

Water Year	MS+SS Loads lbs	DSA Loads lbs	MS+SS % Change from WY 89	DSA % Change from WY 89	MS+SS Conc. ug/L	DSA Conc. ug/L	MS+SS % Change from WY 89	DSA % Change from WY 89
WY 1986	6,638	9,722	-18%	10%	8.6	51	-39%	-15%
WY 1987	7,640	10,741	-6%	22%	12	54	-15%	-10%
WY 1988	8,130	10,097	0.4%	15%	13	57	-8%	-5%
WY 1989	8,099	8,814	0%	0%	14.1	60	0%	0%
WY 1990	7,719	7,485	-5%	-15%	14.6	66	4%	10%
WY 1991	3,899	5,992	-52%	-32%	14	75	-0.7%	25%
WY 1992	2,919	5,119	-64%	-42%	12.6	76	-11%	27%
WY 1993	6,871	8,849	-15%	0.3%	15	81	6%	35%

The increased constituent loading from the DSA is also reflected by increased loads in Mud Slough (north) and Salt Slough. Although salt, boron, and selenium loads remain lower than those in WY 89 (by 14, 10, and 20%, respectively), they have increased dramatically over WY 92 (by 71, 100, and 130%, respectively). The constituent concentrations in Mud Slough (north) and Salt Slough do not reflect these increases in loads. As compared to WY 89, WY 93 showed a slight increase in salt, boron, and selenium concentrations (9, 15, and 1%, respectively). When compared to WY 92, salt demonstrated a slight decrease (13%) while boron remained the same and selenium increased by 15% (or 2 μg/L). The relatively constant concentrations as compared to increasing loads is likely due to an increase in available dilution water during WY 93.

Figures 6-9 show a comparison of monthly average selenium and boron concentrations for the sloughs for WY 89, WY 92, and WY 93. WY 89 is used as a baseline indicator since data available for this time period reflects full water allotments as well as a time period prior to implementation of drainage operation plans in the DSA. In WY 92, drainage water was routed to Salt Slough until mid-June at which time it was routed to Mud Slough (north) until the end of the water year (mid to late September). During WY 93, this alternate routing of the drainage water did not take place which changed the seasonal water quality in both sloughs. The routing of the drainage water had a direct impact on the water quality in each slough and whether selenium and boron concentrations exceeded upcoming Basin Plan objectives. These Basin Plan objectives will come into effect in October 1993 (WY 94) and are outlined in Table 6.

TABLE 6

Water Quality Objectives for Mud and Salt Sloughs (from the Basin Plan)

Constituent	Maximum Concentration	Compliance Date
Selenium (μg/L)	26 10 (monthly mean)	October 1993
Boron (mg/L) (March 15-Sept 15)	5.8 2.0 (monthly mean)	October 1993
Molybdenum (μg/L)	58 19 (monthly mean)	January 1989

Mud Slough (north) receives little dilution water, so, during WYs 89 and 92, it was unable to buffer the diversion of subsurface drainage which resulted in frequent exceedences of upcoming WY 94 objectives. During WY 93, with the absence of subsurface drainage, Mud Slough still exceeded 1994 water quality objectives, but far less frequently than in previous years. The boron objective was exceeded from March through June (Figure 6), the selenium objective in December 1992 (Figure 7), and the molybdenum objective in November and December of 1992 and April of 1993 (Figure 8). Overall monthly mean constituent concentrations were lower in Mud Slough during WY 93 when compared to WY 92 and similar or lower to those seen during WY 89.

Figure 6. Boron Monthly Mean Concentrations in Mud Slough (North).

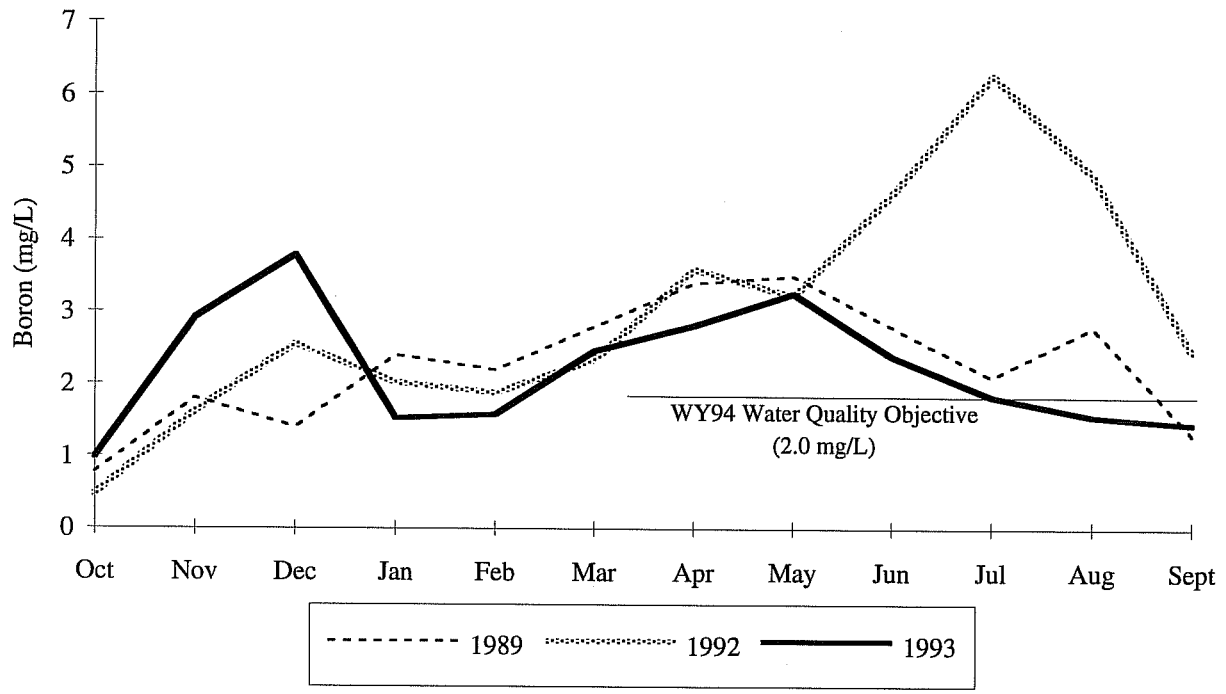


Figure 7. Selenium Monthly Mean Concentrations in Mud Slough (North).

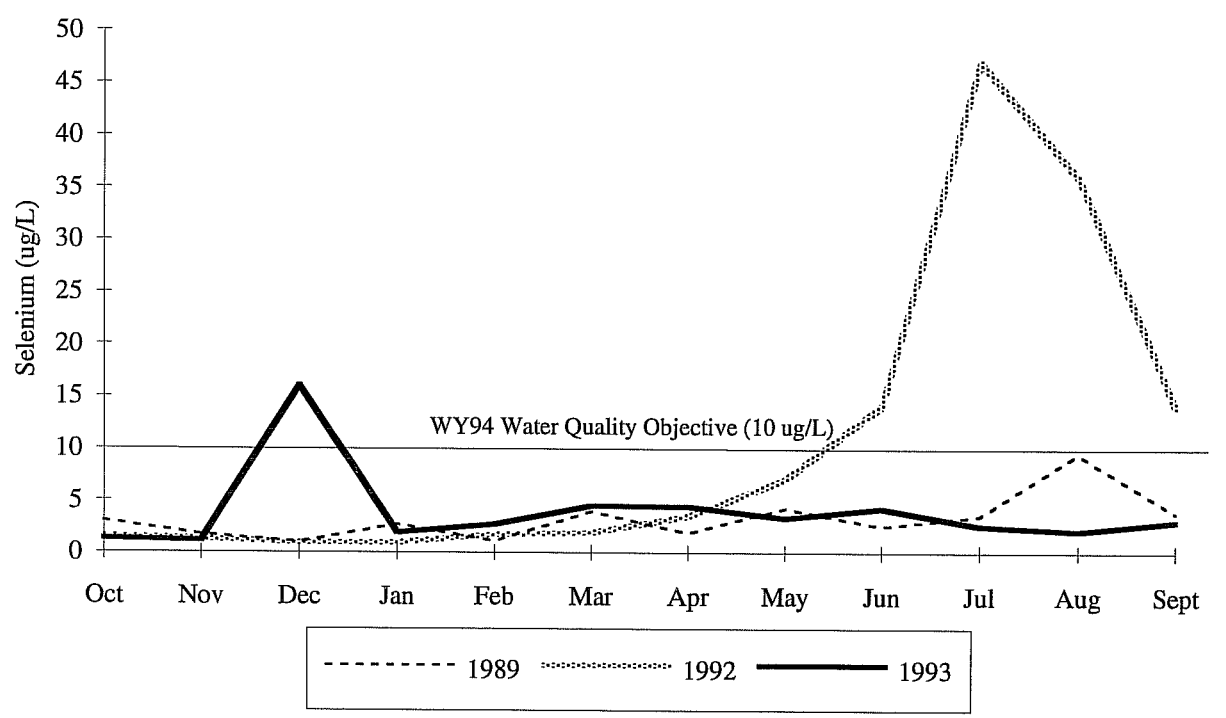


Figure 8. Molybdenum Monthly Mean Concentrations in Mud Slough (North).

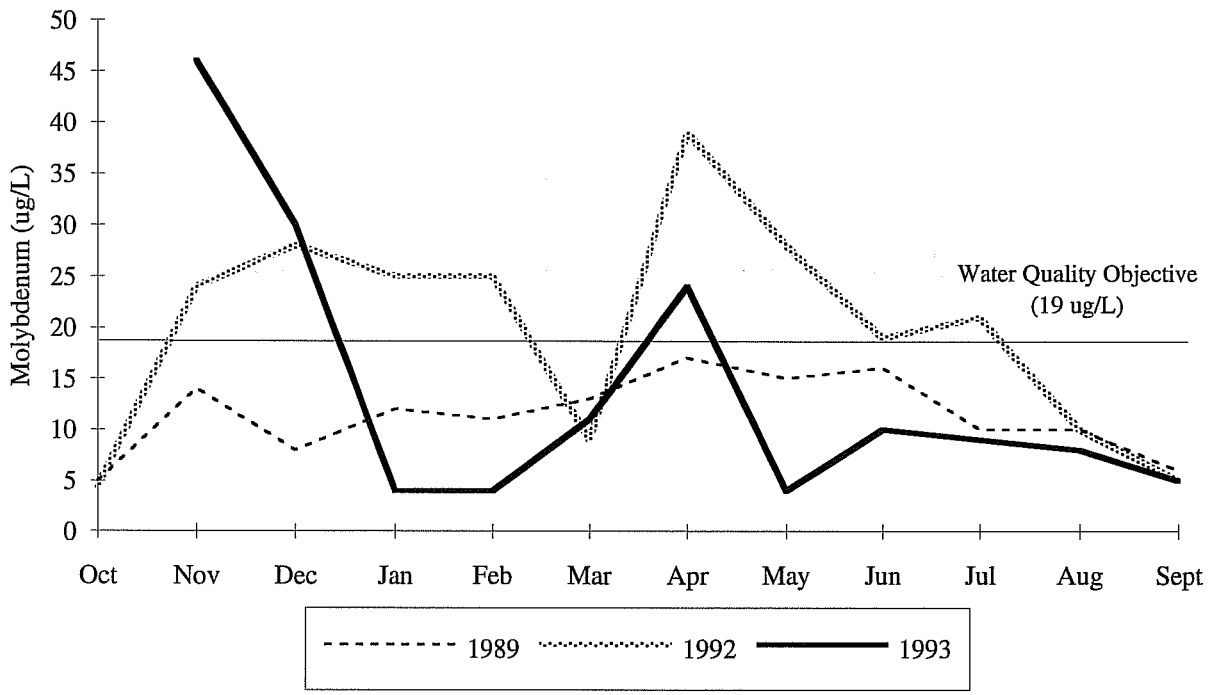
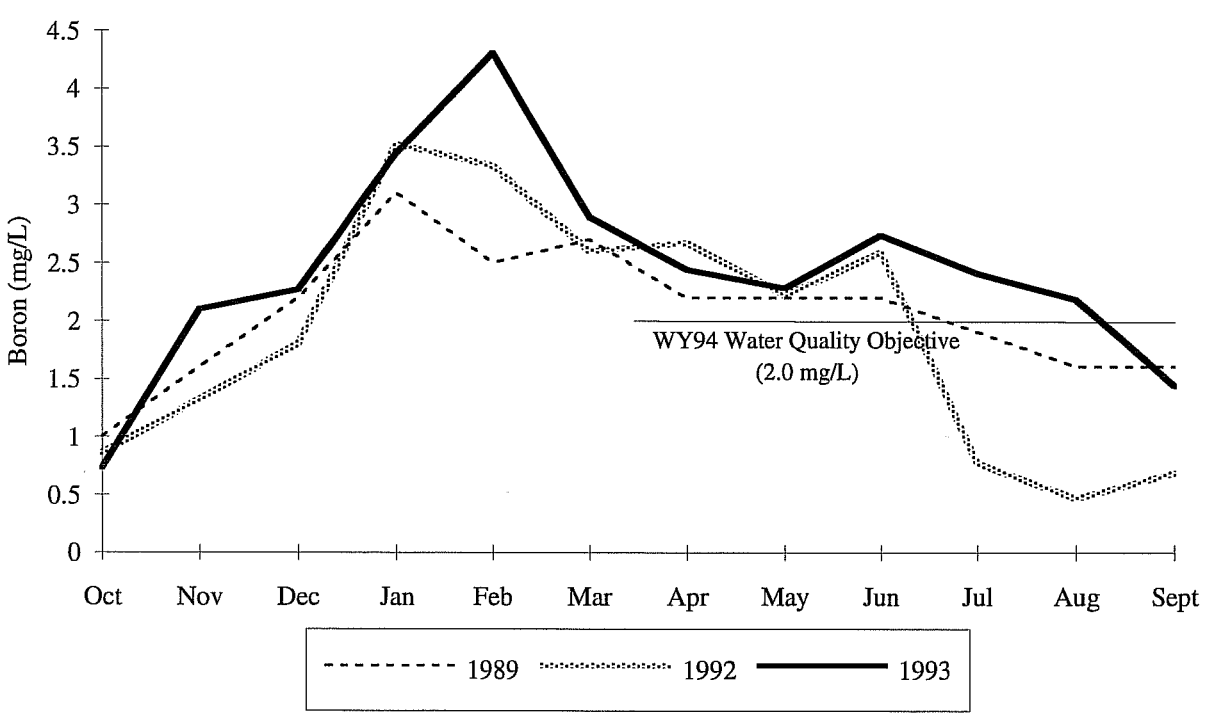


Figure 9. Boron Monthly Mean Concentrations in Salt Slough at Lander Ave.



Retaining the subsurface drainage in Salt Slough caused an overall increase in constituent concentrations in WY 93 when compared to WYs 89 and 92. Boron water quality objectives were exceeded from March through August 1993 (Figure 9), while selenium objectives were exceeded from December 1992 through August 1993 (Figure 10). Molybdenum concentrations remained below the 19 μg/L objective in Salt Slough throughout WY 93 (Figure 11) with the highest concentrations occurring between December 1992 and February 1993.

Based upon the mean monthly constituent concentrations depicted in Figures 6 through 11, the routing of drainage water appears to have a direct influence on whether the proposed WY 94 selenium water quality objective may be exceeded in the future. Removing the subsurface drainage from Mud Slough (north) resulted in low overall selenium concentrations and only a single exceedence in the proposed monthly objective of 10 μg/L. Based on WY 92 trends, removing subsurface drainage from Salt Slough may bring it into compliance with the 10 μg/L selenium objective.

The routing of drainage has less of an impact on the possible compliance of future boron and existing molybdenum water quality objectives with the exception of boron in Salt Slough. Rerouting subsurface drainage from Salt Slough to Mud Slough (north) during the final quarter of WY 92, resulted in compliance with the future objective of 2.0 mg/L boron. Mud Slough (north) was already exceeding 2.0 mg/L boron at the time of the diversion due to elevated background concentrations. Molybdenum, in contrast, has always remained below the existing objective of 19 μg/L in Salt Slough, and sporadically exceeded the objective in Mud Slough (north) regardless of the presence of subsurface drainage.

The selenium water quality objective of 2.0 μg/L which is in effect for waterfowl habitat supply water, appears to have been met during WY 93. As depicted in Figure 12, both the San Luis Spillway and CCID Main Canal remained below 2.0 μg/L selenium during typical periods of duck club flood-ups and irrigation (usually the end of September through December and then again during May and June to irrigate wetland grasses). These two canals are the major sources for wetland supply water. Selenium concentrations did slightly exceed 3.0 μg/L during February and March 1993. These increases appear to correspond with increasing selenium concentrations in the Delta Mendota Canal and Mendota Pool which are the freshwater sources to the area (USBR, 1994).

Figure 10. Selenium Monthly Mean Concnetrations in Salt Slough at Lander Avenue.

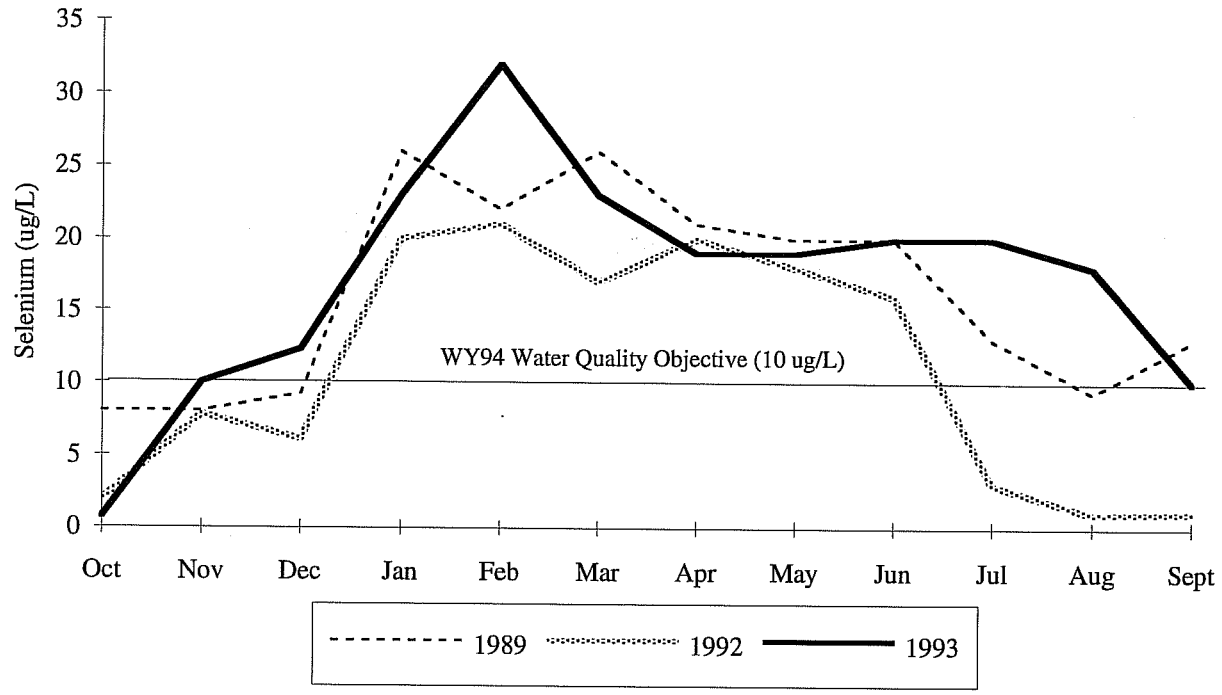


Figure 11. Molybdenum Monthly Mean Concentrations in Salt Slough at Lander Avenue.

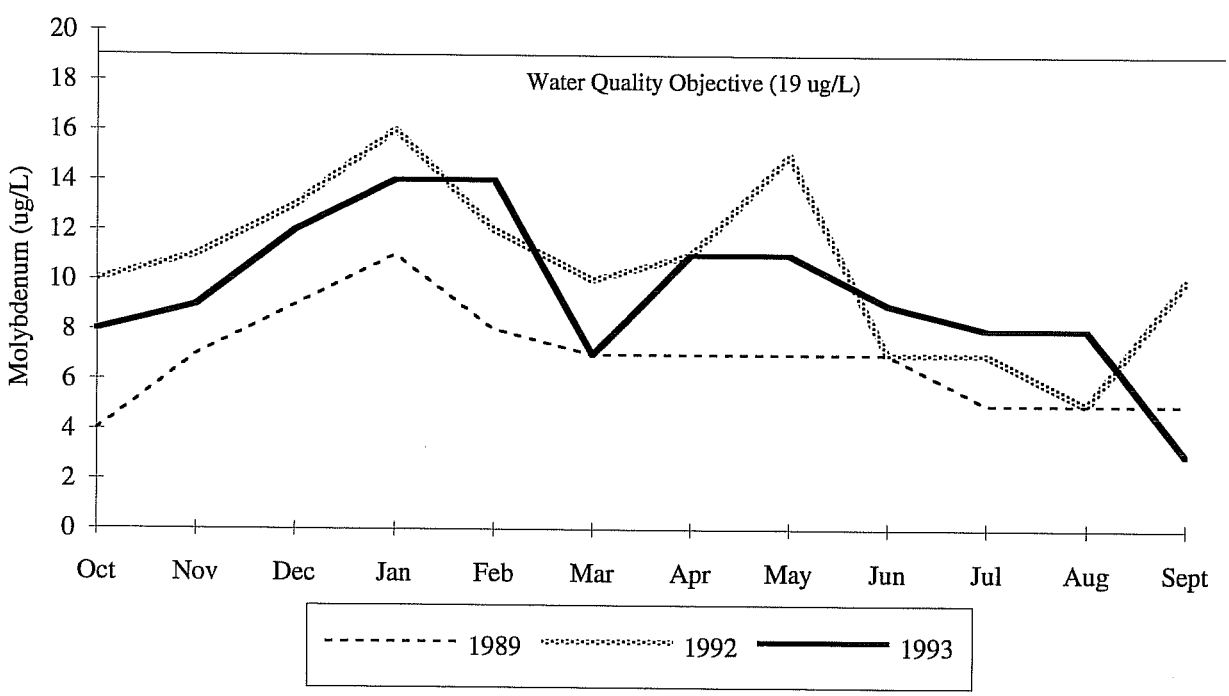
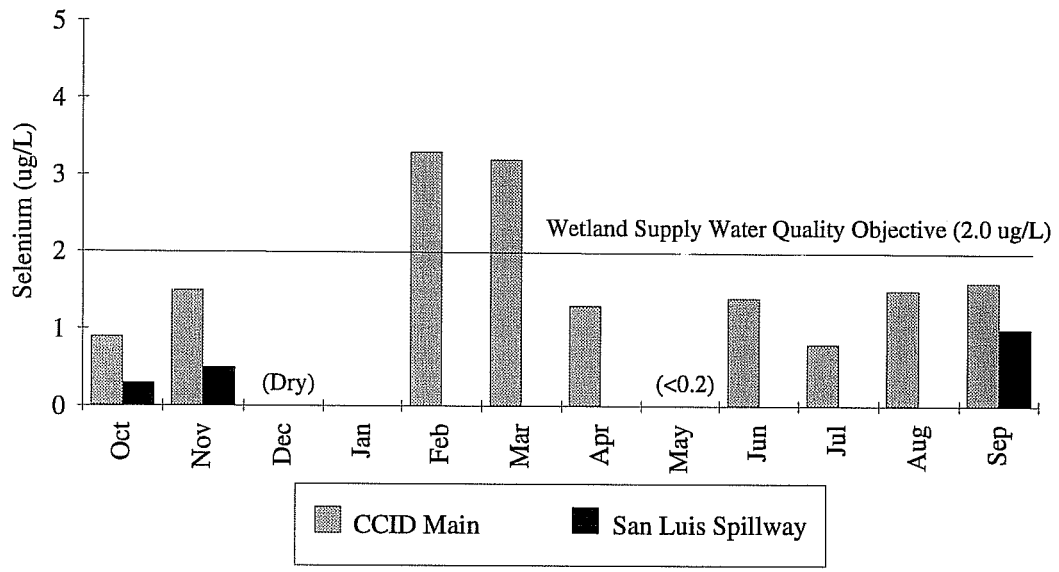


Figure 12. Selenium Concentrations in Water Used to Supply Waterfowl Habitat: WY93.



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Appendix A.

Mineral and Trace Element Water Quality Data for Inflow Monitoring Stations

Main (Firebaugh) Drain at Russell Avenue (MER556)

Location: Latitude 36° 55' 27" Longitude 120° 39' 11". In SW 1/4, SW 1/4. SW 1/4, Sec. 34, T.11S., R. 12E. E side of Russell Avenue., 2.7 mi. S of South Dos Palos

Date	Time	Temp F	pH	EC µmhos/cm	Se	Mo	Cr	Cu	Ni	Pb	Zn	B	Cl	SO4	HDNS
					µg/L							mg/L	mg/L	mg/L	mg/L
10/2/92	750	66	7.5	2920	25							4.5			
10/9/92	1015	66	7.6	3540	38							5.6			
10/16/92	940	61	7.6	5370	64							10.1			
10/23/92	845	61	8.4	5530	78							10.5			
10/30/92	1345	62	8.0	2940	38	17	16	16	<10	<25	34	3.4	342	796	560
11/6/92	745	58	8.0	3260	44							5.0			
11/13/92	747	49	8.0	2980	39							4.1			
11/20/92	835	51		2900	33							3.9			
11/30/92	1015	48	7.8	5110	110	33	32	15	16	<5	20	9.0	575	1680	1280
12/4/92	820	47	8.2	3630	52							5.7			
12/14/92	1415	49	8.2	5780	101							9.0			
12/22/92	825	46	8.0	8740	224							17.9			
12/30/92	1020	52		8540	223	110	24	4	6	<5	10	16.8	869	3330	1780
1/8/93	740	52	7.2	5090	90							6.9			
1/15/93	1050			4370	48							7.1			
1/22/93	915	55	7.7	5080	117							8.5			
1/28/93	1155	48	8.5	7060	176	61	27	10	13	<5	25	12.3	548	2320	1630
2/4/93	1020	54	7.6	5680	145							9.7			
2/10/93	915	54		4430	83							6.3			
2/19/93	1030	55	6.8	3910	72							5.1			
2/25/93	730	54	8.4	6110	148	42	33	14	32	40	39	8.5	659	2120	1360
3/5/93	1010	58	7.5	5900	136							9.7			
3/12/93	935	61	7.6	4900	104							7.3			
3/18/93	755	61	7.9	4030	68							5.5			
3/26/93	930	60	7.5	3440	71	11	26	13	21	<5	72	4.1	396	1020	837
4/2/93	934	59	8.1	6670	174							9.4			
4/9/93	802	62	8.1	5765	118							6.3			
4/16/93	853	60	7.5	4400	81							5.5			
4/23/93	840	60	8.1	4500	96							4.9			
4/30/93	753	68	8.2	4150	79	19	39	13	36	<5	110	4.2	422	1300	893
5/7/93	1045	63	8.1	3090	52							4.0			
5/14/93	839	64	8.1	3070	40							3.8			
5/21/93	931	64	7.9	2900	42							3.5			
5/28/93	744	65	7.7	2830	40	21	19	15	60	<5	<1	3.4	266	839	635
6/4/93	833	66	7.8	3410	63							4.5			
6/11/93	830	62	6.5	6510	130							6.7			
6/18/93	745	74	8.0	3050	46							4.5			
6/25/93	745	75	7.1	2590	33	15	21	15	24	6	<1	3.0	246	746	534
7/2/93	858	78	7.0	3100	37							4.4			
7/9/93	1050	75	7.5	2560	34							3.5			
7/16/93	715	69	7.8	2930	41							4.4			
7/23/93	857	75	7.3	2340	27							3.1			
7/30/93	722	72	7.4	3090	44	19	51	20	42	6	85	5.5	244	972	834
8/6/93		75	7.4	1930	20							2.7			
8/13/93	805	71	7.6	3060	33	17	42	19	34	<5	74	4.7	230	885	688
8/20/93	650	69	7.0	2900	30							5.2			
8/26/93	935	76	7.5	2820	48	14	37	12	27	<5	48	3.9	245	761	653
9/3/93	933	75	7.0	3340	68							5.0			
9/10/93	845	72	7.0	3530	49							5.2			
9/17/93	930	63	7.4	2540	31							3.2			
9/23/93	940	64	7.7	2200	27	12	21	9	<5	17	19	2.8	200	544	487
Count		50	47	51	51	13	13	13	13	13	13	51	13	13	13
Min		46	6.5	1930	20	11	16	4	<5	<5	<1	2.7	200	544	487
Max		78	8.5	8740	224	110	51	20	60	40	110	17.9	869	3330	1780
Mean		62	7.7	4130	75	30	30	13	24	7	41	6.1	403	1130	936
Geo Mean		61	7.7	3870	62	23	28	13	16	3	18	5.5	362	1160	855
Median		62	7.7	3530	52	19	27	14	24	<5	34	5.1	342	972	834

Panoche Drain at O'Banion Gauge Station (MER 501)

Location: Latitude 36° 55' 14" Longitude 120° 41' 43". In SW 1/4, SW 1/4, SW 1/4, Sec. 32. T. 11S R. T. 12E Located 0.5 mi. S of CCID Main Canal, 1.9 mi. W of Russell Road., 5.5 mi. SW of Dos Palos 3.4 SW of South Dos Palos

Date	Time	Temp F	pH	EC µmhos/cm	Se	Mo	Cr	Cu	Ni	Pb	Zn	B	Cl	SO4	HDNS
					µg/L							mg/L	mg/L	mg/L	mg/L
10/2/92	800	64	7.5	5380	60							9.9			
10/9/92	1040	68	7.0	4720	57							8.4			
10/16/92	925	62	7.6	5200	33							9.4			
10/23/92	No Access														
11/2/92	1455		7.1	5180	59	11	83	21	<10	<25	13	10	620	1310	1100
11/6/92	815	58	7.9	5150	44							9.0			
11/13/92	730	50	6.4	5210	63							9.6			
11/20/92	820	50		4000	58							7.6			
11/30/92	1030	50	8.0	4790	31	8	23	3	<5	<5	5	7.5	737	1210	1170
12/4/92	830	48	8.1	4720	30							7.6			
12/14/92	1430	54	8.2	4200	61							6.6			
12/22/92	845	48	8.1	5030	110							8.6			
12/30/92	1010	53		5400	130	11	71	11	12	<5	30	9.0	702	1470	1280
1/8/93	No Access														
1/15/93	No Access														
1/28/93	No Access														
2/4/93	930	51	6.9	4600	67							7.9			
2/10/93	No Access														
2/19/93	No Access														
2/24/93	No Access														
3/12/93	945	58	7.6	4910	77							7.3			
3/18/93	810	57	7.9	5040	110							7.3			
4/2/93	945	59	7.8	4800	76							7.5			
4/9/93	821	60	8.1	5610	132							7.5			
4/16/93	909	58	7.6	5990	150							8.7			
4/23/93	825	60	7.8	5450	140							8.4			
4/30/93	802	64	7.8	6040	140	14	53	6	20	<5	21	9.3	724	1690	1410
5/7/93	1035	62	7.8	5580	110							8.9			
5/14/93	851	61	7.9	5155	91							7.9			
5/21/93	945	64	7.8	5160	100							7.3			
5/28/93	759	63	7.6	4660	84	11	38	15	63	<5	<1	7.1	522	1100	1070
6/4/93	840	64	7.8	4630	63							7.5			
6/11/93	850	64	7.3	4720	74							7.8			
6/18/93	755	69	7.8	4830	86							9.2			
6/25/93	800	70	7.0	5020	80	6	110	14	29	10	<1	7.5	609	1280	1140
7/2/93	911	72	7.0	4360	71							6.9			
7/9/93	1110	72	7.5	4660	81							7.7			
7/16/93	720	64	7.7	4620	76							8.1			
7/23/93	920	72	7.2	4830	81							7.5			
7/30/93	736	68	7.4	4690	93	12	29	14	24	<5	52	7.5	546	1280	1260
8/6/93		72	7.0	4380	75							7.1			
8/13/93	820	68	7.5	4340	66	13	37	9	18	<5	19	7.6	501	1140	1040
8/20/93	700	66	7.1	4510	92							8.5			
8/26/93	1001	74	7.3	4420	88	12	30	4	10	<5	9				
9/3/93	946	74	7.2	4200	76							6.4			
9/10/93	905	70	7.5	4160	68							6.6			
9/17/93	1000	63	7.4	4720	88							7.4			
9/23/93	1000	64	7.5	4970	55	8	25	4	<5	8	4	7.8	683	1340	1500
Count		40	39	41	41	10	10	10	10	10	10	40	9	9	9
Min		48	6.4	4000	30	6	23	3	<5	<5	<1	6.4	501	1100	1040
Max		74	8.2	6040	150	14	110	21	63	10	52	10	737	1690	1500
Mean		62	7.5	4880	81	11	50	10	18	3	15	8.0	627	1310	1220
Geo Mean		62	7.5	4860	76	10	44	8	10	2	6	7.9	621	1300	1210
Median		64	7.6	4800	76	11	38	10	15	<5	11	7.7	620	1280	1170

Agatha Inlet (Mercy Springs) Drain near Panoche Drain (MER552)

Location: Latitude 36° 56' 01". Longitude 120° 42' 05".In SE 1/4. SE 1/4, NW 1/4, Sec. 31, T. 11S., R.12E.
S. of Firebaugh Drain, 3.6 mi. W of Russell Ave., 2.8 mi. S of South Dos Palos

Date	Time	Temp F	pH	EC µmhos/cm	Se µg/L	Cr µg/L	Cu µg/L	Ni µg/L	Pb µg/L	Zn µg/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L	TDS mg/L
11/2/92	1505		7.7	4760	53	7	13	<10	<25	46	8.8	520	1180	1000	3420
11/30/92	1035	49	8.1	4800	29						7.9	745	1200	1260	
Count		1	2	2	2	1	1	1	1	1	2	2	2	2	1
Min		49	7.7	4760	29	7	13	<10	<25	46	7.9	520	1180	1000	3420
Max		49	8.1	4800	53	7	13	<10	<25	46	8.8	745	1200	1260	3420
Mean		49	7.9	4780	41	7	13	<10	<25	46	8.4	633	1190	1130	3420
Geo Mean		49	7.9	4780	40	7	13	<10	<25	46	8.4	622	1190	1122	3420
Median		49	7.9	4780	41	7	13	<10	<25	46	8.4	633	1190	1130	3420

Agatha Canal at Mallard Road(MER506)

Location: Latitude: 36° 56' 12", Longitude 120° 42' 07" In NE1/4, NW1/4, SW1/4, Sec. 7 T.11S, R.11E
South of Santa Fe Grade at Brito, West of Mallard Road. 4.5 miles west of Dos Palos.

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	Mo µg/L	Cu µg/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L
10/9/92	1145	72	7.6	990	2.0			0.68			
10/16/92	1005	64	7.7	980	1.7			0.69			
10/23/92	925	66	8.2	1080	3.2			0.78			
10/30/92	1440	65	8.3	4270	43			7.0	530	1080	875
11/6/92	850	60	8.0	4930	41			9.8			
11/13/92	805	52	7.8	5000	60			8.6			
11/20/92	845	50		4430	36			7.6			
11/30/92	1055	52	8.3	1380	5.0	4		1.4	204	235	331
12/4/92	855	51	8.4	1300	5.8			1.2			
12/14/92	1325	49	8.4	3940	37			6.4			
12/22/92	915	47	8.5	1310	2.4			1.5			
12/30/92	935	50		1850	4.3	5		2.3	249	390	382
1/8/93	800	54	7.3	4490	87			8.0			
1/15/93	1030			2800	<.2			<1			
1/22/93	930	54	8.0	3760	51			6.1			
1/28/93	1135	50	8.5	5220	104			8.4	618	1510	1220
2/4/93	1040	54	7.5	4630	68			8.2			
2/10/93	930	55		3050	40			5.3			
2/19/93	1050	54	6.4	1360	6.1			1.6			
2/25/93	805	55	8.1	5200	110	12		8.9	678	1550	1370
3/5/93	950	59	7.6	1580	3.6			2.1			
3/12/93	1005	63	7.5	1090	3.9			2.3			
3/18/93	910	62	7.6	4240	60			6.1			
3/26/93	950	59	7.8	1390	6.6			1.5	189	233	312
4/2/93	1020	62	7.9	1060	7.5			1.5			
4/9/93	912	63	8.0	5310	55.5			8.8			
4/16/93	930	58	7.9	6600	8.3			15			
4/23/93	900	60	8.2	5380	120			9.1			
4/30/93	825	66	8.0	5710	77	27		9.5	674	1580	1310
5/7/93	1100	68	8.0	4830	39			8.0			
5/14/93	909	65	8.3	780	1.5			0.47			
5/21/93	913	66	7.8	3790	59			5.4			
5/28/93	825	66	7.8	4300	64	10		7.1	545	1180	1010
6/4/93	920	67	8.1	2870	9.3			4.6			
6/11/93	910	68	7.6	2570	5.3			4.3			
6/18/93	820	74	8.4	760	3.4			0.71			
6/25/93	825	76	7.5	3870	55	10		5.5	437	1030	835
7/2/93	932	78	7.3	3800	52			6.2			
7/9/93	1130	78	7.4	1190	4.4			1.4			
7/16/93	855	65	8.6	333	2.9			0.34			
7/23/93	944	76	7.8	3600	50			6.0			
7/30/93	800	68	7.6	3770	51	21		5.9	414	1060	895
8/6/93	929	78	7.5	3280	40			5.8			
8/13/93	846	70	8.0	1050	5.1	2		1.4	102	199	242
8/20/93	720	69	7.6	1340	5.4			2.4			
8/26/93	1035	76	8.0	378	2.0	1					
9/3/93	1010	77	7.3	3850	74			6.2			
9/10/93	935	74	7.5	3410	47			5.5			
9/17/93	1025	69	8.2	422	2.2		12	0.25			
9/23/93	1040	72	8.0	392	1.5	1	10	0.23	35.3	45.4	111
	Count	49	46	50	50	10	2	49	12	12	12
	Min	47	6.4	333	<0.2	1	10	0.23	35.3	45.4	111
	Max	78	8.6	6600	120	27	12	15	678	1580	1370
	Mean	63	7.9	2900	32	9	11	4.7	390	841	741
	Geo Mean	63	7.8	2230	13	6	11	3.0	299	562	583
	Median	65	7.9	3170	23	8	11	5.4	426	1045	855

Hamburg Drain near Camp 13 Slough (MER504)

Location: Latitude: 36° 56' 20" Longitude 120° 45' 26". In SE 1/4, SE 1/4 SW 1/4, Sec 27. T.11S., R.11E
50ft. S of CCID main canal, 9.2 mi. S-SE of Los Banos, 6.7 mi. W-SW of South Dos Palos

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	Mo µg/L	Cr µg/L	Cu µg/L	Ni µg/L	Pb µg/L	Zn µg/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L
10/2/92	720	58	7.6	5020	71							6.8			
10/9/92	910	62	7.8	4370	49							6.3			
10/16/92	855	62	7.7	3830	38							5.1			
10/23/92	810	58	7.1	4130	49							5.0			
10/30/92	1235	65	8.5	4620	65	9	13	6	<10	<25	36	7.0	759	1300	1270
11/6/92	705	58	7.9	4990	88							6.3			
11/13/92	837	53	7.9	4790	83							5.3			
11/20/92	900	50		2700	11							2.7			
11/30/92	945	49	7.8	3000	15	8	45	38	54	33	35	3.4	272	1120	1380
12/4/92	755	42	7.7	3510	31							3.9			
12/14/92	1350	56	8.6	4550	73							5.0			
12/22/92	753	48	6.5	4700	73							5.1			
12/30/92	910	55		4820	72	10	18	1	9	<5	2	5.6	636	1430	1550
1/15/93	No Access														
1/22/93	900	60	7.3	4350	52							4.7			
1/28/93	1105	53	8.4	5200	62	5	37	8	10	<5	24	7.3	677	1600	1820
2/4/93	845	50	6.9	5470	87							5.9			
2/10/93	830	60		4450	51							5.0			
2/19/93	No Access														
2/24/93	1720	63	8.4	5430	76	6	21	3	<5	43	14	6.8	779	1670	1700
3/5/93	910	59	6.7	5020	83							5.3			
3/12/93	906	59	7.1	4730	65							5.1			
3/18/93	725	57	7.0	5100	78							5.4			
4/2/93	900	58	7.6	5800	90							6.8			
4/9/93	725	58	8.1	6020	89							6.8			
4/16/93	820	50	6.3	6310	150							7.7			
4/23/93	810	56	8.3	3740	24							4.5			
4/30/93	722	61	7.7	4140	66	9	41	9	22	<5	32	5.8	687	1340	1480
5/7/93	1000	62	8.0	5560	84							6.4			
5/14/93	815	60	7.6	5790	95							6.6			
5/21/93	825	59	8.3	4400	69							4.4			
5/28/93	7.17	58	7.3	3230	21	11	<5	8	40	<5	<1	3.6	292	1180	1240
6/4/93	805	65	7.2	5960	101							6.7			
6/11/93	808	68	6.4	4720	75							NA			
6/18/93	650	66	7.7	4520	75							4.9			
6/25/93	715	66	6.6	4160	46	10	6	2	7	9	3	4.8	433	1360	1350
7/2/93	832	68	5.3	6680	143							7.3			
7/9/93	1030	70	7.2	6520	136							7.5			
7/16/93	655	61	7.7	6600	140							7.0			
7/23/93	829	72	6.5	7480	200							7.8			
7/30/93	655	67	6.7	7290	189	8	29	9	16	<5	28	9.2	938	2040	2380
8/6/93	825	68	5.5	6590	140							6.8			
8/13/93	735	65	7.0	6180	122	4	55	15	22	<5	35	7.3	831	1680	1830
8/20/93	625	62	5.4	4850	73							6.8			
8/26/93	902	68	6.8	5990	115	8	37	6	17	<5	21	7.9	896	1630	2100
9/3/93	908	74	6.2	6390	136							8.3			
9/10/93	815	72	6.1	6760	154							8.5			
9/17/93	855	68	6.5	6480	141							7.7			
9/23/93	855	66	7.2	6350	138	9	11	2	<5	<5	<1	8.7	856	1960	2180
Count		47	44	47	47	12	12	12	12	12	12	46	12	12	12
Min		42	5.3	2700	11	4	<5	1	<5	<5	<1	2.7	272	1120	1240
Max		74	8.6	7480	200	11	55	38	54	43	36	9.2	938	2040	2380
Mean		61	7.2	5176	87	8	26	9	17	8	19	6.1	671	1530	1690
Geo Mean		60	7.2	5047	74	8	19	6	10	3	8	5.9	626	1500	1650
Median		60	7.3	5020	76	9	25	7	13	<5	23	6.4	723	1520	1630

NA=data fell outside of acceptable quality control guidelines

Camp 13 Slough at Gauge Station (MER505)

Location: Latitude 36° 56' 21" Longitude 120° 45' 22". In SE 1/4, SE 1/4, SW 1/4, Sec. 27 T.11S., R.11E. 150 Ft. N of CCID Main Canal, 6.4 mi. W of Russell Avenue., 9.2 mi SE of Los Banos, 6.7 mi SW of South Dos Palos

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	Mo µg/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L
10/2/92	730	68	7.8	998	3.0		0.68			
10/9/92	930	70	7.7	910	2.3		0.51			
10/16/92	905	66	8.8	900	1.6		0.46			
10/23/92	820	65	8.0	3320	22		5.1			
10/30/92	1240	64	8.4	3700	46	32	6.0	406	1050	785
11/6/92	715	58	8.0	3700	46		5.5			
11/13/92	847	52	8.0	4240	57		6.2			
11/20/92	905	51		3510	32		5.2			
11/30/92	950	52	8.5	1270	5.3	4	1.1	195	220	275
12/4/92	800	46	8.2	4350	70		6.5			
12/14/92	1355	56	8.6	4110	62		6.8			
12/22/92	800	46	6.9	5540	120		9.3			
12/30/92	915	50		4770	100	21	8.0	593	1440	1180
1/15/93	No Access									
1/28/93	1105	54	8.5	5200	64	5	8.2	651	1530	1990
2/4/93	850	50	7.2	4900	56		6.9			
2/19/93	No Access									
2/24/93	1730	60	8.3	5470	74	12	7.3	757	1720	1610
3/5/93	925	58	6.9	5240	102		7.6			
3/12/93	915	60	7.0	4730	77		7.0			
3/18/93	730	62	7.7	4630	91		5.9			
4/2/93	905	61	7.9	5220	93		7.5			
4/9/93	739	62	7.9	6510	140		8.7			
4/16/93	834	58	6.1	6010	110		7.6			
4/23/93	805	63	8.1	4730	110		6.1			
4/30/93	730	69	8.1	4880	90	19	6.6	570	1340	1085
5/7/93	1015	64	7.8	4590	89		6.6			
5/14/93	824	64	7.9	4300	69		6.5			
5/21/93	830	66	8.5	713	2.5		0.38			
5/28/93	724	66	7.7	3010	24	19	4.1	327	782	641
6/4/93	815	67	7.4	4110	58		6.7			
6/11/93	820	67	6.1	4280	59		7.4			
6/18/93	715	73	7.7	4080	64		6.2			
6/25/93	725	71	7.4	628	1.7	1	0.34	70.4	85.5	140
7/2/93	840	77	6.3	4160	50		6.8			
7/9/93	1035	75	7.5	3880	56		5.8			
7/16/93	700	68	7.7	3890	57		5.4			
7/23/93	840	76	7.5	830	11		0.64			
7/30/93	700	70	7.0	4020	66	9	6.7	469	1190	1090
8/6/93	830	74	6.3	3340	44		5.1			
8/13/93	740	70	7.4	3600	42	9	6.3	387	892	885
8/20/93	630	67	6.3	3260	47		5.5			
8/26/93	910	74	7.2	3360	47	11	5.8	374	890	886
9/3/93	917	78	7.3	497	2.4		0.36			
9/10/93	830	76	7.4	489	2.8		0.38			
9/17/93	910	63	7.1	3820	54		6.6			
9/23/93	910	64	7.6	3480	46	8	6.1	421	943	991
	Count	45	43	45	45	12	45	12	12	12
	Min	46	6.1	326	1.6	1	0.34	70.4	85.5	140
	Max	78	8.8	6510	140	32	9.3	757	1720	1990
	Mean	64	7.6	3560	55	13	5.3	435	1010	963
	Geo Mean	63	7.5	2870	34	9	3.9	379	801	799
	Median	64	7.7	4020	56	10	6.2	414	997	939

Charleston Drain at CCID Main Canal (MER502)

Location: Latitude 36° 56' 59" Longitude 121° 46' 48". In NE 1/4, SE 1/4, NE 1/4 Sec. 29, T.11S., R. 11E
N side of CCID Main Canal, 8.7 mi S-SE of Los Banos, 7.9 mi. W-SW of South Dos Palos

Date	Time	Temp F	pH	EC µmhos/cm	Se	Mo	Cr	Cu µg/L	Ni	Pb	Zn	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L
10/2/92	715	64	7.3	1830	10							1.5			
10/9/92	900	68	7.1	1050	4.0							0.54			
10/16/92	840	65	8.4	1010	3.4							0.50			
10/23/92	800	64	6.7	1040	3.9							0.55			
10/30/92	1220	63	7.9	2180	19	4	6	147	22	<25	116	2.0	232	504	610
11/6/92	655	58	7.8	2910	23							2.6			
11/30/92	935	49	7.4	3760	40	12	6	5	<5	<5	14	3.6	426	1230	1260
12/4/92	745	49	6.9	3920	38							3.8			
12/30/92	No Access														
1/28/93	1115		8.4	5220	84	6	16	7	6	<5	20	5.3	777	1640	1540
2/4/93	830	50	6.5	5640	100							6.4			
2/24/93	1715	61	8.2	4960	84	5	29	20	16	149	48	5.6	740	1450	1720
4/30/93	712	64	7.7	4980	68	11	15	5	10	<5	39	4.9	610	1450	1610
5/28/93	708	62	7.0	5190	90	13	<5	12	70	<5	<1	5.0	685	1590	1590
6/25/93	705	70	5.9	5740	108		20	7	16	11	11	5.4	735	1700	1740
7/30/93	645	68	6.3	5090	106	7	24	11	14	<5	47	5.5	703	1480	1660
8/13/93	723	70	6.6	4220	80	11	14	5	10	<5	10	3.9	513	1120	1190
8/26/93	850	69	6.3	4090	73	5	26	7	15	<5	26	4.4	462	1360	1380
9/23/93	835	60	6.7	4930	73	9	7	2	<5	<5	7	6.1	718	1420	1640
Count		17	18	18	18	10	11	11	11	11	11	18	11	11	11
Min		49	5.9	1010	3.4	4	<5	2	<5	<5	<1	0.50	232	504	610
Max		70	8.4	5740	108	13	29	147	70	149	116	6.4	777	1700	1740
Mean		62	7.2	3760	56	8	15	21	17	16	31	3.7	600.1	1360	1450
Geo Mean		62	7.1	3260	35	8	11	9	10	3	16	2.9	570.6	1300	1400
Median		64	7.0	4160	70	8	15	7	14	<5	20	4.2	685	1450	1590

Almond Drive Drain (MER555)

Location: Latitude 36° 59' 55" Longitude 120° 49' 00". In SW 1/4, SW 1/4, SW 1/4, Sec. 6. T.11S., R.11E. N side of Almond Dr., 1.1 mi E of Mercy Springs Drain, 100ft. E of CCID Main Canal, 4.7 mi. S. of Los Banos

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	Mo µg/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L
10/30/92	1205	64	8.3	900	0.6		0.39	139	119	187
11/30/92	915	52	7.2	910	1.3		0.43	157	103	177
12/30/92	825	50		2400	2.7		2.8	272	512	518
1/28/93	1035	52	8.6	3230	5.6		4.4	343	806	683
2/24/93	1700	64	8.4	2410	5.0		3.1	283	555	586
3/26/93	825	58	7.6	1920	6.1		1.9	228	396	445
4/30/93	700	68	8.3	614	2		0.35	69.3	85.5	138
5/28/93	655	60	7.1	1120	2.0		0.92	123	172	269
6/25/93	650	72	5.6	678	1.6	9	0.36	79.5	93.3	144
7/30/93	626	64	6.0	783	1.9		0.70	90.9	120	196
8/13/93	709	72	7.1	562	1.6		0.36	64.6	80.0	138
8/26/93	830	74	6.5	379	1.2		0.27	35.9	47.0	110
9/23/93	816	68	7.0	460	1.9		0.27	48.9	61.2	125
	Count	13	12	13	13	1	13	13	13	13
	Min	50	5.6	379	0.60	9	0.27	35.9	47.0	110
	Max	74	8.6	3230	6.1	9	4.4	343	806	683
	Mean	63	7.3	1260	2.6	9	1.2	149	242	286
	Geo Mean	62	7.2	1000	2.1	9	0.76	119	159	233
	Median	64	7.2	900	1.9	9	0.43	123	119	187

Rice Drain at Mallard Road (MER509)

Location: Latitude 36° 59' 22" Longitude 120° 14' 42". In NE 1/4, NW 1/4, SW 1/4, Sec. 7, T.11S., R11E
South of Santa Fe Grade at Brito, 50 ft. West of Mallard Road, 4.5 mi. West of Dos Palos

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	Mo µg/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L
10/2/92	815	66	7.5	2420	3.0		3.7			
10/9/92	1140	72	7.5	1070	2.4		0.85			
10/16/92	955	64	7.7	1800	1.4		2.9			
10/23/92	920	62	8.5	1920	2.5		2.8			
10/30/92	1450	63		2390	4.7		4.1	279	617	594
11/6/92	845	58	8.2	2250	3.0		3.7			
11/30/92	1050	49	8.2	2780	10	7	4.3	388	673	650
12/4/92	850	47	8.2	3220	2.9		7.8			
12/30/92	940	50		3360	1.4	12	7.4	378	948	720
1/28/93	1140	46	8.6	3080	2.8	12	5.7	417	754	673
2/25/93	800	52	7.8	3270	2.6		6.1	406	862	740
3/26/93	1000	60	7.6	2070	2.2		4.2	242	509	493
4/30/93	823	69	7.8	2490	4.0	14	4.7	218	641	585
5/28/93	819	66	8.0	1860	2.4	18	3.4	172	503	353
6/25/93	820	76	7.5	2480	3.1	18	4.7	240	659	525
7/30/93	756	71	7.7	2030	2.6	12	4.3	193	528	485
8/13/93	842	71	7.8	1890	1.9	10	3.5	176	461	401
8/26/93	1045	74	7.6	1990	2.4	14	3.7	182	430	466
9/23/93	1050	66	7.6	1720	1.5	6	3.4	157	400	441
	Count	19	17	19	19	10	19	13	13	13
	Min	46	7.5	1070	1.4	6	0.85	157	400	353
	Max	76	8.6	3360	10	18	7.8	417	948	740
	Mean	62	7.9	2320	3.0	12	4.3	265	614	548
	Geo Mean	61	7.9	2240	2.7	12	3.9	250	594	535
	Median	64	7.8	2250	2.6	12	4.1	240	617	525

Boundry Drain at Department of Fish and Game Pump (MER521)

Location: Latitude 37° 06' 32" Longitude 120° 46' 44" In NE 1/4, SE 1/4, NE 1/4. Sec. 32., T.9S., R11E. North of Henry Miller Road. 4.6 mi. NE of Los Banos

Date	Time	Temp F	pH	EC µmhos/cm	Se µg/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L
10/30/92	1110	62	8.3	1130	0.5	0.58	184	146	242
11/30/92	1155	54	8.1	1380	1.0	0.48	259	176	256
12/30/92	No Access								
1/28/93	1345	54	8.3	3440	1.0	1.2	658	491	722
2/24/93	No Access								
4/30/93	956	68	7.9	1200	2.5	0.51	179	149	248
5/28/93	945	66	8.1	955	0.8	0.32	141	88.7	184
6/25/93	1005	76	7.7	1460	1.3	0.68	218	192	279
7/30/93	911	74	7.9	840	1.4	0.37	111	90.7	191
8/13/93	1000	71	8.0	875	1.4	0.37	128	99.5	194
8/27/93	854	74	7.3	948	1.6	0.43	126	105	222
9/24/93	850	66	7.4	866	0.6	0.4	96.4	86.7	215
Count		10	10	10	10	10	10	10	10
Min		54	7.3	840	0.5	0.32	96.4	86.7	184
Max		76	8.3	3440	2.5	1.2	658	491	722
Mean		67	7.9	1310	1.2	0.53	210	162	275
Geo Mean		66	7.9	1180	1.1	0.49	177	139	251
Median		67	8.0	1040	1.1	0.46	160	126	232

Salt Slough Ditch at Hereford Road (MER528)

Location: Latitude 37° 08' 30" Longitude 120° 45' 17" In NW 1/4, NE 1/4, NW 1/4, Sec. 22 T.9S., R11E. 3.0 mi. N on Hereford Road from Henry Miller Road

Date	Time	Temp F	pH	EC µmhos/cm	Se µg/L	Cu µg/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L
10/2/92	845	68	7.5	1070	0.5		0.40			
10/9/92	1335	74	7.6	1140	0.3		0.44			
10/16/92	755	66	7.8	1060	0.3		0.29			
10/23/92	1030	64	8.0	920	0.6		0.27			
10/30/92	1050	61	8.2	1180	0.2		0.34	164	123	289
11/6/92	930	60	8.3	1050	1.1		0.45			
11/30/92	1140	51	8.1	1100	0.8		0.35	158	108	204
12/30/92	750	48		1080	3.0		0.49	164	144	214
1/28/93	1400	51	8.5	1400	3.5		0.44	189	252	264
2/24/93	1620	59	8.2	1120	1.4		0.57	168	171	255
3/26/93	1105	60	7.3	1020	1.8		0.40	149	127	242
4/30/93	1015	68	7.6	1060	1.1		0.36	138	120	244
5/28/93	1000	67	7.8	603	0.5		0.19	73.4	55.3	141
6/25/93	1025	80	7.4	1070	0.6		0.35	153	126	231
7/30/93	928	74	7.6	751	0.9		0.33	91.4	80.3	181
8/13/93	1010	70	7.6	834	0.9		0.31	115	96.2	193
8/27/93	915	76	7.2	702	0.4		0.35	89.1	81.5	184
9/17/93	1125	67	8.0	737	1.0	6	0.28			
9/24/93	940	68	7.6	653	0.7	5	0.27	66.7	65.2	163
	Count	19	18	19	19	2	19	13	13	13
	Min	48	7.2	603	0.2	5	0.19	66.7	55.3	141
	Max	80	8.5	1400	3.5	6	0.57	189	252	289
	Mean	65	7.8	976	1.0	6	0.36	132	119	216
	Geo Mean	64	7.8	954	0.8	5	0.35	126	110	212
	Median	67	7.7	1060	0.8	6	0.35	149	120	214

Appendix B.

Mineral and Trace Element Water Quality Data for Internal Flow Monitoring Stations

CCID Main at Russell Avenue (MER510)

Location: Latitude 36° 55' 28" Longitude 120° 39' 11" In SE 1/4, SE 1/4, SE 1/4, Sec. 33 T.11S., R12E. 2.7 mi. south of Dos Palos

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	Cu µg/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L
10/2/92	745	68	7.6	845	0.7		0.42			
10/9/92	1000	72	7.5	830	0.8		0.34			
10/16/92	935	66	7.8	830	0.6		0.34			
10/23/92	845	65	8.7	820	1.0		0.35			
10/30/92	1345	65	8.4	950	1.3		0.47	148	114	191
11/6/92	745	60	8.3	915	1.8		0.47			
11/30/92	1015	53	8.3	840	1.1		0.36	149	90.4	164
12/30/92	DRY									
1/28/93	1155	48*	8.5*	3370*	4.2*		5.8*	304*	1110*	1100*
2/25/93	735	53	8.5	820	3.3		0.67	90.0	160	216
3/26/93	920	59	7.8	1185	3.2		0.70	177	173	259
4/30/93	753	68	8.4	521	1.3		0.27	58.0	66.3	124
5/28/93	744	65	8.5	99.2	<0.2		0.06	6.8	10.6	26
6/25/93	740	72	7.4	682	1.4		0.42	85.5	103	166
7/30/93	722	72	7.9	355	0.8		0.24	32.1	47.1	93
8/13/93	800	74	8.0	566	1.5		0.35	68.0	75.5	145
8/26/93	945	76	7.8	464	1.4		0.30	48.5	60.2	119
9/17/93	940	69	7.9	337	1.5	12	0.19			
9/23/93	930	70	8.0	383	1.6	10	0.22	39.6	49.1	113
	Count	17	17	17	17	2	17	11	11	11
	Min	53	7.4	99.2	<0.2	10	0.06	6.8	10.6	26
	Max	76	8.7	1185	3.3	12	0.70	177	173	259
	Mean	66	8.0	673	1.4	11	0.36	82	86	147
	Geo Mean	66	8.0	594	1.1	11	0.32	62	71	129
	Median	68	8.0	820	1.3	11	0.35	68	75.5	145

* Ponding occured on this date and data is not included in summary calculations

San Luis Spillway Ditch @ Santa Fe Grade (MER537)

Location: Latitude 37° 08' 37.2" Longitude 120° 52' 22.9" In SE 1/4, SE 1/4, Sec. 16, R.10E, T.9S.
3.4 miles north west of the intersection of Mercy Springs Road and old Santa Fe Grade
5.5 miles north of Los Banos.

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	Cu µg/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L
10/2/92	915	70	7.5	795	0.3		0.29			
10/9/92	1405	72	7.5	730	0.3		0.25			
10/16/92	1055	65	8.3	720	0.3		0.19			
10/23/92	1050	66	8.1	760	0.3		0.32			
10/30/92	930	62	8.2	980	0.2		0.54	155	80.4	216
11/6/92	950	62	8.0	1110	0.3		0.66			
11/13/92	937	54	8.4	1260	0.7		0.76			
11/30/92	820	50		1370	0.6		0.95	225	143	239
9/17/93	1150	63	8.1	597	1.5	4	0.41			
9/24/93	810	68	7.3	376	0.5	6	0.22	37.1	32.4	115
	Count	10	9	10	10	2	10	3	3	3
	Min	50	7.3	376	0.2	4	0.19	37.1	32.4	115
	Max	72	8.4	1370	1.5	6	0.95	225	143	239
	Mean	63	7.9	870	0.5	5	0.46	139	85.3	190
	Geo Mean	63	7.9	818	0.4	5	0.40	109	72.0	181
	Median	64	8.1	778	0.3	5	0.37	155	80.4	216

Appendix C.

Mineral and Trace Element Water Quality Data for Outflow Monitoring Stations

Mud Slough at Newman Gun Club (MER551)

Location: Latitude 37° 18' 33" Longitude 120° 57' 18" In NW 1/4, NW 1/4, SW 1/4, Sec. 23, T.7S., R.9E., 1.7 mi. NE of Santa Fe Grade, 1.2 mi. N of Hwy 140. 4.2 mi. NE of Gustine

Date	Time	Temp F	pH	EC µmhos/cm	Se	Mo	Cr	Cu	Ni	Pb	Zn	B	Cl	SO4	HDNS
					µg/L							mg/L	mg/L	mg/L	mg/L
10/2/92	1115	72	8.0	1380	4.1							0.94			
10/9/92	930	64	8.0	1510	4.8							1.0			
10/16/92	1255	72	8.4	1740	3.8							1.2			
10/23/92	1245	73	8.7	1720	3.8							1.1			
10/29/92	830	62	8.0	1900	2.9							1.4	298	313	385
11/5/92	1620	68	8.1	2390	2.4							1.8			
11/30/92	1030	50		4850	3.2							3.6	778	1050	842
12/30/92	1010	47		3790	34							4.7	536	954	824
1/28/93	800	45	8.7	1640	1.1							1.1	220	260	169
2/24/93	1405	56	8.0	1350	2.9	4						1.2	168	241	301
3/26/93	1325	60	7.7	3130	5.0	9						2.8	497	566	594
4/30/93	1304	74	8.5	3260	3.0							2.6	436	555	525
6/25/93	1345	91	8.0	2150	2.2	10						1.7	265	382	346
7/30/93	1209	86	8.5	3000	1.4							2.3	411	636	547
8/20/93	1000	76	7.6	1450	1.4							1.1			
9/17/93	1405	72	8.4	1980	4.4							1.5			
9/24/93	1255	81	8.4	2600	1.0		6	2	<5	<5	4	2.0	353	560	492
Count		17	15	17	17	3	1	1	1	1	1	17	10	10	10
Min		45	7.6	1350	1.0	4	6	2	<5	<5	4	0.94	168	241	169
Max		91	8.7	4850	34	10	6	2	<5	<5	4	4.7	778	1050	842
Mean		68	8.2	2340	4.8	8	6	2	<5	<5	4	1.9	396	552	503
Geo Mean		66	8.2	2180	3.1	7	6	2	<5	<5	4	1.7	362	493	457
Median		72	8.1	1980	3.0	9	6	2	<5	<5	4	1.5	382	558	509

Mud Slough at San Luis Drain (MER542)

Location: Latitude 37° 19' 50" Longitude 120° 57' 03". In NW 1/4, NE 1/4, NW 1/4, Sec. 14 T.7S., R.9 5.0 miles east of Gustine, 3.5 miles SE of Hwy 140. Located inside of Kesterson N.W.R.

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	Mo µg/L	Cr µg/L	Cu µg/L	Ni µg/L	Pb µg/L	Zn µg/L	B mg/l	Cl mg/l	SO4 mg/l	HDNS mg/l
10/2/92	1000	68	7.8	810	1.4							0.27			
10/9/92	1440	72	8.4	890	1.4							0.51			
10/16/92	1125	66	8.2	1210	1.4							0.74			
10/23/92	1120	66	7.9	1670	1.1							1.1			
10/30/92	845	62	7.5	2710	1.0		<5	14	<10	<25	8	2.3	378	495	516
11/6/92	1125	64	7.9	2930	1.3							2.2			
11/13/92	1005	53	7.9	3780	1.1							2.8			
11/30/92	845	50		5000	0.8	46	5	6	<5	<5	5	3.8	840	1070	864
12/4/92	955	51	8.0	4220	1.8							3.2			
12/14/92	1150	48	8.3	2560	1.9							1.9			
12/22/92	1100	49	8.1	4810	2.4							3.7			
12/30/92	1130	52		4750	59	30	6	2	<5	<5	4	6.4	622	1240	1050
1/8/93	945	56	7.8	3380	3.0							3.0			
1/15/93	1230			1270	1.8							0.95			
1/22/93	1130	53	8.3	1130	1.7							1.1			
1/28/93	930	46	8.4	1530	0.9	4	17	6	11	<5	11	1.0	215	216	156
2/4/93	1230	52	7.9	2330	1.5							2.0			
2/10/93	1125	55		1380	2.5							1.3			
2/19/93	1235	56	7.7	2210	2.3							1.8			
2/24/93	1445	57	8.1	1270	4.3	4	19	10	21	36	26	1.3	147	225	290
3/5/93	1155	60	7.8	1440	1.8							1.3			
3/12/93	1240	66	7.8	3020	2.5							2.3			
3/18/93	1120	63	7.9	3050	1.7							2.4			
3/26/93	1220	60	7.7	3840	12	11	9	4	8	<5	20	3.9	631	780	695
4/2/93	1220	65	8.0	2060	9.4							2.1			
4/9/93	1312	67	8.1	2910	5.7							2.8			
4/16/93	1109	65	8.1	2850	1.8							2.4			
4/23/93	1025	63	8.1	3350	3.4							2.9			
4/30/93	1102	70	8.0	4700	1.8	24	6	2	10	<5	7	4.0	690	884	816
5/7/93	1125	70	8.0	5510	5.5							4.1			
5/14/93	1039	68	7.8	7250	1.1							4.9			
5/21/93	1130	72	7.9	4020	2.7							2.8			
5/28/93	1041	70	7.6	1300	3.7	4	14	6	32	<5	<1	1.2	146	238	265
6/4/93	1105	71	8.0	2630	8.3							2.5			
6/11/93	1055	73	7.9	2590	4.5							2.4			
6/18/93	1005	72	7.8	4120	2.2							3.2			
6/25/93	1110	78	7.5	1850	1.6	10	6	4	10	6	<1	1.5	242	316	293
7/2/93	1130	80	8.6	1800	3.2							1.4			
7/9/93	825	72	7.3	2150	2.5							1.6			
7/16/93	1055	72	8.2	2010	2.6							1.8			
7/23/93	1215	81	7.8	3420	1.8							2.5			
7/30/93	1019	73	7.3	2470	3.0	9	18	5	14	<5	9	1.9	343	491	451
8/6/93		74	7.9	2510	2.9							1.8			
8/13/93	1053	75	7.2	1900	1.3	7	12	5	10	<5	11	1.4	252	356	359
8/20/93	840	70	7.6	1330	1.4							0.97			
8/27/93	1006	72	7.0	3500	2.6	8	27	5	22	<5	17	2.1	434	616	554
9/3/93	1230	80	7.8	1740	1.9							1.2			
9/10/93	1200	75	7.7	2480	2.2							1.7			
9/17/93	1235	66	8.1	1840	7.0			7				1.4			
9/24/93	1030	64	7.8	2170	0.9	5	20	5	<5	14	10	1.5	277	403	454
Count		49	46	50	50	12	13	14	13	13	13	50	13	13	13
Min		46	7.0	810	0.8	4	<5	2	8	<5	<1	0.27	146	216	156
Max		81	8.6	7250	59	46	27	14	32	36	26	6.4	840	1240	1053
Mean		65	7.9	2710	3.9	14	12	6	11	6	10	2.2	401	564	520
Geo Mean		64	7.9	2410	2.4	10	10	5	7	2	6	1.9	345	480	457
Median		66	7.9	2500	2.0	9	12	5	10	<5	9	1.9	343	491	454

Los Banos Creek at State Highway 140 (MER554)

Location: Latitude 37° 16' 35" Longitude 120° 57' 14". In NE 1/4, SW 1/4, SW 1/4, Sec. 35, T.7S., R.9E. South side of Highway 140, 2.9 mi. NE of Gustine

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L
10/29/92	805	60	8.4	1170	0.7	0.66	193	85.9	281
11/30/92	1005	45		2990	0.4	1.5	479	397	647
12/30/92	1040	45		2830	0.4	1.2	464	361	472
1/28/93	835	45	8.5	1850	0.6	1.6	240	300	224
2/4/93	1205	53	7.8	2230	0.7	2.2			
2/24/93	1515	57	8.2	990	1.1	0.73	111	151	232
3/26/93	1200	60	7.5	1340	1.2	1.3	182	193	278
4/30/93	1230	74	8.0	2070	1.4	2.1	293	218	335
5/28/93	1143	74	8.2	1615	0.9	1.4	204	226	293
6/25/93	1255	90	8.0	1660	1.7	1.4	178	316	341
7/30/93	1127	75	8.4	1310	1.3	1.1	177	156	280
8/12/93	1445	81	7.9	948	1.5	0.72	99.8	146	237
8/27/93	1123	76	7.9	863	1.1	0.56	86.6	86.0	205
9/24/93	1155	70	8.4	641	0.7	0.37	60.5	100	172
	Count	14	12	14	14	14	13	13	13
	Min	45	7.5	641	0.4	0.37	60.5	85.9	172
	Max	90	8.5	2990	1.7	2.2	479	397	647
	Mean	65	8.1	1610	1.0	1.2	213	210	307
	Geo Mean	63	8.1	1460	0.9	1.1	180	186	289
	Median	65	8.1	1480	1.0	1.3	182	193	280

Salt Slough at Lander Avenue (State Highway 165) (MER531)

Location: Latitude 37° 14' 55" Longitude 120° 51' 04". In NW 1/4, SE 1/4, SE 1/4, Sec. 10, T. 8S., R.10E. 13.0 mi. north of Los Banos, 5.0 mi. south of Highway 140.

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	Mo µg/L	Cr µg/L	Cu µg/L	Ni µg/L	Pb µg/L	Zn µg/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L
10/2/92	1015	68	7.6	1540	0.5							0.71			
10/9/92	1030	65	7.9	1650	0.8							0.67			
10/16/92	1220	70	8.1	2140	0.6							0.79			
10/23/92	1205	65	8.2	1800	0.7							0.70			
10/29/92	740	62	8.1	1880	0.7	8	<5	10	<10	<25	50	0.79	350	248	361
11/6/92	1010	62	7.9	2180	9.5							1.9			
11/13/92	1025	54	8.0	2910	15							3.6			
11/30/92	900	47		2190	0.6	9	5	3	<5	<5	5	0.88	431	280	383
12/4/92	1020	49	8.2	1870	0.7							0.70			
12/14/92	1110	45	8.6	3030	23							3.9			
12/22/92	1120	47	8.2	3500	24							3.4			
12/30/92	1115	49		2910	1.6	12	<5	1	<5	<5	4	1.1	548	388	488
1/8/93	1030	56	7.9	3160	21							3.0			
1/15/93	1145			2870	23							3.4			
1/22/93	1035	56	8.4	2620	15							3.0			
1/28/93	905	47	8.1	3350	31	14	9	4	6	<5	10	4.4	462	770	645
2/4/93	1125	52	7.5	3970	42							5.0			
2/4/93	1125	52	7.5	3970	42							5.1			
2/10/93	1040	56		2860	23							3.9			
2/19/93	1155	55	7.3	3230	25							3.7			
2/24/93	1555	57	7.8	3270	27	14	19	9	13	76	23	3.9	466	809	771
3/5/93	1110	61	7.8	3500	29							3.7			
3/12/93	1135	64	7.2	3270	24							3.1			
3/18/93	1145	65	8.0	2940	23							2.6			
3/26/93	1240	60	7.6	2150	15	7						2.2	311	434	524
4/2/93	1253	64	7.6	2660	18							2.6			
4/9/93	1334	68	8.1	3070	21							2.9			
4/16/93	1145	64	8.1	2860	27							2.8			
4/23/93	1050	64	7.8	1670	7.9							1.3			
4/30/93	1150	72	7.9	2660	23	11	13	4	10	<5	20	2.6	343	544	573
5/7/93	1155	69	8.1	2550	24							2.4			
5/14/93	1118	69	7.9	2170	19							2.3			
5/21/93	1200	72	7.9	2710	21							2.8			
5/28/93	1111	70	7.7	1720	9.6	11	<5	5	23	<5	<1	1.7	228	329	339
6/4/93	1030	70	8.1	1950	14							2.1			
6/11/93	1015	72	8.0	2550	20							3.0			
6/18/93	1035	76	8.2	2800	27							3.3			
6/25/93	1205	80	7.4	2210	17	9	13	8	13	<5	9	2.5	259	450	493
7/2/93	1038	80	7.5	2270	22							2.6			
7/9/93	930	77	8.3	2450	23							2.9			
7/16/93	1120	73	8.6	1890	19							2.1			
7/23/93	1117	76	7.9	1900	17							2.1			
7/30/93	1046	76	7.6	1900	17	8	16	7	11	<5	26	2.4	200	368	451
8/6/93		80	7.9	1910	18							2.4			
8/12/93	1400	78	5.9	1820	16	9	17	7	11	<5	3	2.1	216	382	395
8/20/93	900	72	7.4	1680	15							2.1			
8/27/93	1043	76	7.5	1880	22	7	23	6	15	<5	21				
9/3/93	1310	81	7.7	1560	11							1.5			
9/10/93	1340	80	7.5	1760	16							2.1			
9/17/93	1255	68	7.9	1820	11			6				1.7			
9/24/93	1105	70	7.9	905	1.6	3	13	10	<5	10	16	0.51	114	112	204
Count		50	47	51	51	13	12	13	12	12	12	50	12	12	12
Min		45	5.9	905	0.5	3	<5	1	<5	<5	3	0.51	114	112	204
Max		81	8.6	3970	42	14	23	10	23	76	50	5.1	548	809	771
Mean		65	7.8	2430	17	9	11	6	9	9	16	2.5	327	426	469
Geo Mean		64	7.8	2340	11	9	7	5	6	2	9	2.1	301	381	446
Median		67	7.9	2270	18	9	13	6	11	<5	13	2.5	327	385	470